Goal 2: Reduce exposures to health hazards associated with major risks of occupational illness in construction

Introduction

Unlike the case for injuries, meaningful national statistics are not available to guide all occupational health research. However, national estimates suggest that occupational illness is an important problem and that the total burden from the number of deaths due to occupational illness is likely to exceed that for occupational injury by a factor ranging from 4 to 11 [Steenland et al. 2003].

Construction researchers rely on the picture provided by a variety of sources such as national data, state-level illness statistics, knowledge (and extrapolation) of construction exposures, and international surveillance findings. Limited death certificate studies are available. While these data tend to underestimate deaths associated with occupational disease, they do suggest that health hazards remain under-controlled. For example, construction was the most frequently-listed industry on asbestosis and silicosis death certificates from 1990 to 1999 (24.6 and 13.4% respectively).[1]

Asbestos is an example of an important health hazard that was previously addressed and so has not been a major focus of the Construction Program during the period covered by this review. NIOSH has focused on asbestos since its inception and assisted OSHA with development of several standards including a rule for asbestos in construction in 1994. Asbestos exposure is possible when previously installed materials are disturbed during renovation and demolition of pre-1970s buildings. However, awareness of asbestos hazards is higher than for other substances, the OSHA standard is comprehensive, and we are not aware of any major gaps related to construction exposures or controls. NIOSH did evaluate issues related to asbestos-containing vermiculite from Libby, Montana and developed guidance in 2003 for those who might come across vermiculite during home renovation work. NIOSH has also recently undertaken an effort to prepare a “roadmap” to identify and fill remaining scientific knowledge gaps on asbestos and the Program will monitor these developments.

The Construction Program has focused on several industry-related occupational illnesses. These include hearing loss, silicosis, skin disorders, and health effects associated with lead exposures, asphalt fumes, and welding fumes. Given the limited national data on the incidence and prevalence of occupational illnesses, exposure findings serve as an important surrogate measure for evaluating occupational health risks. Accordingly, a major focus of the Construction Program has been to follow a sequence of exposure-driven activities including:

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[1] See http://www2a.cdc.gov/drds/WorldReportData/pdf/Table01-06.pdf and http://www2a.cdc.gov/drds/WorldReportData/pdf/Table03-06.pdf

-Develop or improve methods to evaluate exposures.
-Identify exposures associated with construction tasks likely to be of concern.
-Target high exposure tasks to develop effective controls and work practices.
-Raise awareness about hazards and disseminate information on hazards and controls to the construction community.

The Construction Program is also engaged in toxicology, epidemiology, and risk assessment studies to understand the health risks associated with exposure levels.

Awareness about health hazards is often lower than injury hazard awareness because there are frequently few warning properties of the hazard. “In place” hazards such as lead paint or silica can cause exposures when disturbed during renovation or demolition but don’t come with a warning label such as that found on a chemical drum. In addition, most chronic occupational illnesses have a delayed onset. Resulting illnesses are spread over time and various worksites. Associated costs are rarely borne by the industry. Regulations can serve to increase awareness of hazards, provide a common framework for industry practice, and increase the implementation of prevention measures but due to a variety of external factors, several important construction health hazards have not yet been regulated.

In summary, the Program has worked to develop the evidence basis and infrastructure for prevention of a variety of health hazards. Safety and health professionals are using this information to reduce construction health hazards and greater impacts will follow as more research-to-practice products are developed and awareness increases.

Reference

Kyle Steenland , Carol Burnett , Nina Lalich , Elizabeth Ward , Joseph Hurrell 2003. Dying for work: The magnitude of US mortality from selected causes of death associated with occupation AJIM Vol 43(5) 461-482

Sub goal 2.1 Noise Exposure and Hearing Loss

A) Issue

Because construction work involves extensive use of heavy equipment and power tools, harmful noise exposures are common. All construction workers are at risk for exposure to harmful levels of noise. The risk of material hearing impairment is significantly higher than for industrial workers and increases with the duration of trade work. Hearing loss caused by exposure to noise is endemic among construction workers, with a life time probability of developing hearing loss averaging 60 % among all trades and up to 80 % in some trades [Dement et al. 2005]. Hearing loss was identified as an important problem at national construction conferences early in the history of the Construction Program and it has been a priority issue for research and interventions.

Hearing loss is generally well understood and measurement of exposures and primary health effects is relatively straightforward. Model regulatory approaches that reduce noise sources and rely on training, hearing protection, and audiometric testing to protect workers have been available for more than two decades. The effectiveness of occupational hearing conservation programs was determined more than 30 years ago, [Pell 1973] and while such programs have been shown in other countries to have a substantial impact on hearing loss to other industries, their adoption in the construction industry in the U.S. is the exception rather than the rule [CPWR 2002, Schneider 1995]. OSHA required hearing conservation in general industry settings in the 1983 but did not address construction, and this continues to be the case today. What should be a preventable illness remains a widespread problem in construction.

Construction Program and Center researchers have addressed data gaps in construction to improve understanding of construction noise sources and health impacts. Demonstration projects have examined issues related to worker training, hearing conservation, engineering noise control, impulsive noise, and effective use of hearing protection. The Construction Program seeks to provide the evidence basis needed for employers, workers, and safety and health professionals in construction to increase the use of noise control and hearing conservation programs that will ultimately reduce the toll of hearing loss among construction workers. This information will also inform the regulatory process when OSHA moves forward with hearing conservation provisions for construction.

B) Activities

Program researchers from several disciplines including physicists, engineers, audiologists, epidemiologists and others, have addressed construction noise exposures and hearing loss.

Exposure Characterization/Methods Research

Program researchers have systematically characterized field-based noise exposure data for various construction trades. These studies have used task-based exposure assessment. Noise exposure profiles for many individual construction tasks have been collected and published. [Neitzel et al, 2001; Suter 2002] These include: cutting, jack-hammering, drilling, blasting, spraying, paving, chipping, earth moving, grinding, spraying, and pile driving among other tasks. Other noise exposure data (see Table 2.1.1) have been collected during evaluations of residential construction [Methner 2000; Methner et al, 2000].

Table 2.1.1 Noise exposures measured in residential construction.

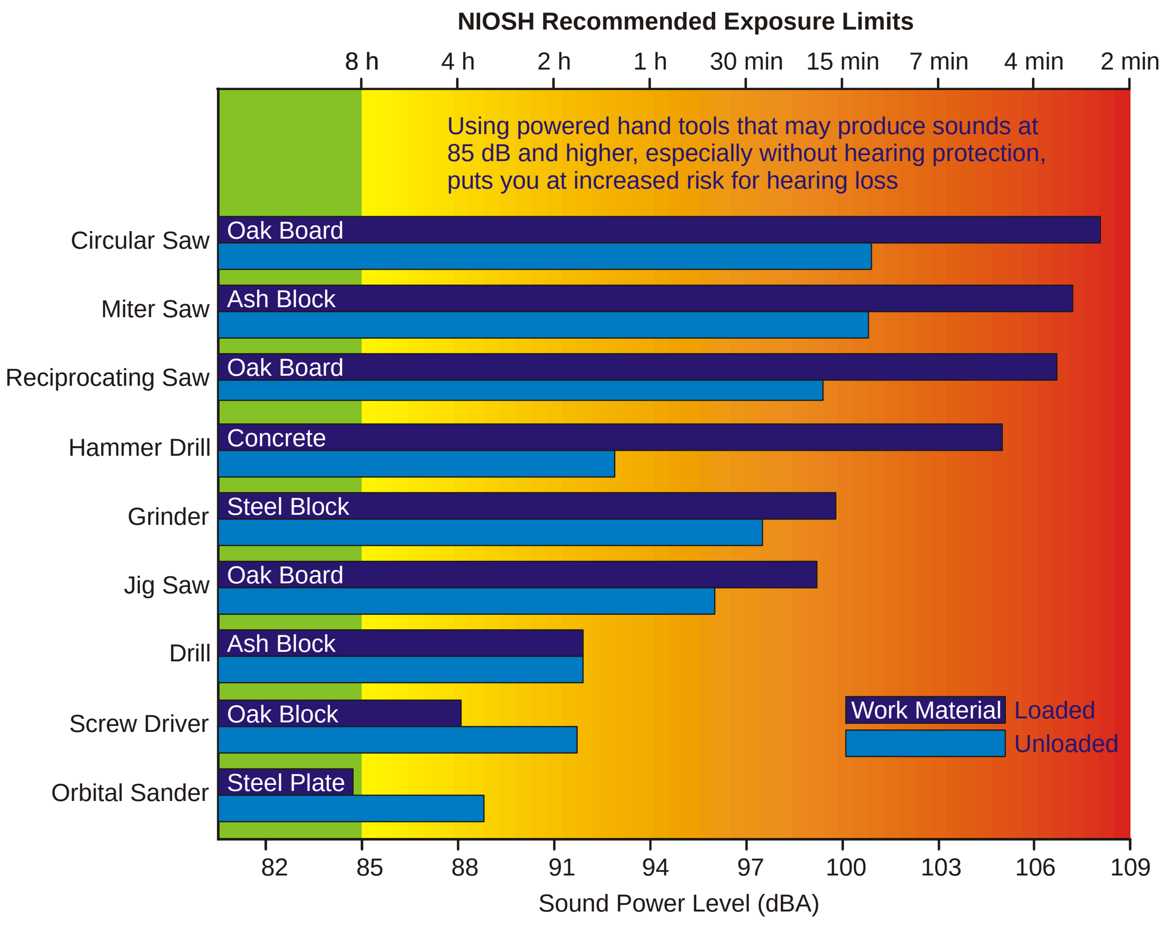
Trade	Task	Duration	Exposure (dBA)
HVAC	Installing/assembling sheet metal	Impact – riveting sheet metal	99
Framing/ Carpentry	Securing siding	Impact – nail gun	115
Roofing	Installing shingles	Impact – nail gun	115
Framing/ Carpentry	Inside work	Sawing, continuous exposure	>90
Various Trades	Various	A radio on inside a house	87
Framing/ Carpentry	Moving supplies with a bobcat	Up to one hour at a time	93
Framing/ Carpentry	Cutting siding	Continuous – Circular saw operated for 3 to 5 second with 1 to 20 minutes or more intervals of no operation	103
Framing/ Carpentry	Cutting 2x4	Continuous – Jig saw operated for 3 to 5 seconds with 1 to 20 minutes or more intervals of no operation	97 - 103
Carpet/ Flooring	Cutting tiles	Continuous – Circular saw operated for 3 to 5 seconds with 1 to 20 minutes or more intervals of no operation	97
Foundation pouring	Cutting concrete	Continuous – Concrete cutter operated for up to 45 minutes	100 - 105

Task-based exposure characterization is particularly useful for addressing construction noise where intermittent noise exposures are common. For example, standing next to a vibrating truck bed during asphalt off-loading operations is very noisy (105 dBA), and can exceed allowable exposures after only 2-6 minutes. Program researchers characterizing construction noise tasks have also collected information regarding the awareness of construction workers of noisy tasks. [Kerr et al, 2002]

Real-time workplace noise characterization has shown that noise exposures tend to be highly episodic with relatively short-duration but extremely high-peak characteristics, and that workers are also likely to be exposed to noise as by-standers (e.g., an electrician exposed to noise from a tool used by a plumber). Construction Program researchers have investigated impulsive noise since the late 1980s. Impulsive noise is generally considered to be more damaging than continuous noise and there are limitations related to accurately measuring impulsive noise and comparing the results to existing standards.

Given the important contribution made by powered hand tools (see Figure 2.1.1) to construction noise exposures, additional work has focused on characterizing sound power levels for common powered tools [Hayden et al, 2005].

Figure 2.1.1 Comparisons of the mean sound power levels for each type of powered hand tools tested in the loaded and unloaded positions. (The NIOSH recommended exposure limit is 85 dBA.)



Health Effects Research
While the relationship between noise and hearing loss is generally well-established, researchers have addressed data gaps related to early development of noise-induced permanent threshold shift (NIPTS) from non-steady-state noise exposures. In 1999, Construction Program-supported researchers followed a cohort of approximately 300 young construction apprentices and student controls for four years. They characterized their NIPTS risk factors, work activities, noise exposures, and hearing ability -- using both standard audiometric hearing threshold levels, (HTLs), and distortion product otoacoustic emissions, (DPOAEs). The study suggests that even with less than three years of exposure, construction apprentices exposed to noise levels under 90 dBA have small (about 0.5 dB per year) but measurable decreases in hearing function, even without clear changes in audiometric HTLs [Seixas et al, 2005].

Engineering and Work Practice Interventions:
Beginning in 2001, the Construction Program focused efforts on engineering controls. A primary focus of the engineering work has been to develop control techniques for powered hand tools. After identifying the highest noise producing equipment, the program investigated the effectiveness and feasibility of existing engineering noise controls. Where controls did not exist, engineering controls were designed and tested. We also worked to encourage adoption of these noise controls through collaborations and dissemination activities with government agencies, unions, equipment manufacturers, standard's setting bodies, employers and employees.

Research has also addressed large air rotary drills used to bore vertical holes for such purposes as drilling water and environmental monitoring wells, gathering geological information, and creating blast holes during mining and construction projects. Field investigations of drill rigs and audiogram tests of operators have shown that operators of air rotary drill rigs are overexposed to noise. [Reinke et al, 2006] Construction program researchers have developed two practical engineering controls and several training tools to reduce hearing loss among these workers. One engineering control, which will reduce sound levels in the operator's cab, can be easily retrofitted onto drill rigs in production. The other control, referred to as the "partial-cab," will protect operators on drill rigs not having a cab, from sound levels above 90 dBA. These engineering noise controls are able to reduce an operator's daily noise dosage (time-weighted average for 8 hours) by 112% to 570%. [Reinke et al, 2006]

Another Program project designed noise and vibration control approaches, tested them in the laboratory, and identified devices for further development. The project identified the most promising noise and vibration control concepts, optimized and implemented the design on a tool, and demonstrated the results under realistic conditions [Key-Schwartz 2006; Kadam 2006].

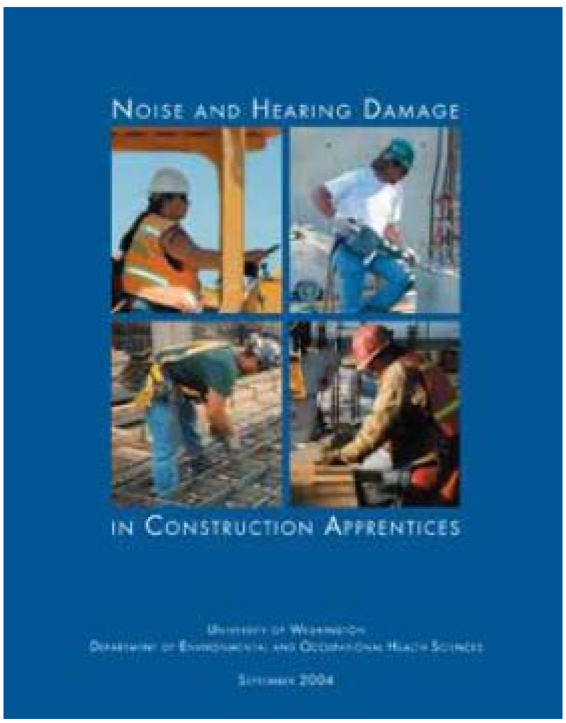
Work practice strategies can provide important approaches for reducing construction noise exposures. The BuildItSmart Labor Management organization in Washington State, which is part of the Construction Center consortium, has identified practical solutions to reducing noise exposures on the job. These include moving noisy equipment as far away from the work zone as practical ("Move It!"), developing makeshift noise barriers, from plywood, styrofoam, or plastic sheeting over a simple frame ("Block It!") or reducing noise levels by properly maintaining or retrofitting tools ("Fix It!"). Much of this information is available on www.elcosh.org.

Education, Training, and Guidelines

Recognizing the need for individual construction workers to assume more responsibility for protecting their hearing by using hearing protection devices (HPDs), we conducted a three-phase study to address this issue at the Training Center for Local 324 of the International Union of Operating Engineers in a Midwestern state. This study was the first we know of to combine computer-based self-administered audiometric tests with tailored hearing protection intervention and audiometric test results. High levels of participant satisfaction demonstrated that computer-based screening and training is a promising modality for training workers [Hong et al, 2005;Hong et al, 2004].

Other Construction Program supported studies evaluated the effectiveness of training programs (including videos, pamphlets, and practice sessions) and a health promotion model to increase the use of HPDs among carpenters, operating engineers, and plumbers/pipefitters. The researchers examined worker perceptions of the percentage of time they were exposed to high noise on construction jobs and compared the data across trade groups. Consistent use of HPDs was low for all three trade groups and that other factors including exposure, demographics, and trade group membership should be used to design effective hearing conservation programs. Other factors such as value of HPD use, barriers to use, and self efficacy were found to be important predictors of HPD use..[Lusk 1999] [Lusk et al, 1997]

The Construction Program developed and maintained information systems dedicated to translating research findings into usable recommendations for the construction and mining industries. Technical staff worked with noise scientists to develop research results into technical and lay documents for website distribution. Writers, editors, website experts, graphic artists and other staff collaborated to produce a website for stakeholders about noise control and hearing loss prevention. Several construction-related items on the site include the searchable power tool noise database and a noise meter. Effectiveness of the website is being assessed by measuring use of the site, user satisfaction, and workplace changes implemented as a result of interaction with the site. The site is updated regularly [NIOSH 1997].



Coordination/Collaboration
Program researchers partnered with the UBC Health and Safety Fund, the Homebuilders of Greater St. Louis, Hayden Homes (a major homebuilder in St. Louis) and McBride and Son (a major construction contractor employed by Hayden) in a surveillance effort to measure hazardous noise for specific construction work tasks. [Susi 1998]

The Construction Program has supported the annual Allied Construction Industries (ACI), -OSHA safety day conference since 2000. The ACI is a local Cincinnati construction trade association that includes representatives from 600 companies. Because of this partnership, the Construction Program has gained access to many construction sites for testing equipment and methods, obtaining noise measurements, sampling worker exposures, and making training videos.

The United Brotherhood of Carpenters (UBC) and Joiners of North America investigated the risk for occupational hearing loss among carpenters and millwrights, and developed interventions to prevent occupational hearing loss for these workers. The UBC/Construction Program partnership had access to carpenters and millwrights during apprentice training activities and at worksites to allow development of a hearing loss prevention program that became a model for the construction industry. The study showed that a training program positively influenced attitudes and beliefs about preventing occupational hearing loss and increased worker skills at fitting and using hearing protectors.

University researchers (Michigan Tech University, Penn State University, University of Cincinnati, and Purdue University) supported by the Construction Program investigated and identified noise sources on air compressors, grinders, circular saws, table saws, nail guns, shop vacuums, impact wrenches, and jigsaws. The researchers made recommendations to reduce noise emissions from each of the tools.[Hayden et al 2003] [Byrne et al 2003] [Benjamin et al 2002] http://www.cdc.gov/niosh/topics/noise/collegeStudents/studentpresentations.html

A national Construction Noise Control Partnership is focusing on the problem and led by the Laborers Health and Safety Fund of North America was started at CPWR. [IHSFNA 1997]

An example and case study of coordination and collaboration among researchers and stakeholders on noise and hearing loss is described in Box 2.1 below.

Box 2.1.1 – Washington State Collaboration Case Study
In Washington State, excessive noise exposures are common in the construction trades, [Neitzel et al, 1999; Seixas et al, 2001] and the rate of hearing loss claims in the industry is approximately five times higher than the average rate for all industries combined [Daniell et al, 2002]. Three unique circumstances in the Washington state fostered a coordinated approach to improve performance on construction hearing loss issues: (1) a specific occupational safety and health regulation for noise in construction, (2) a workers' compensation system that provides payments for disability due to noise-induced hearing loss, and (3) influence from the nearby Canadian Province of British Columbia, which has a long-standing and effective industry-wide hearing conservation program. [NHCA 1998] Key events in the collaboration are: • In 1997, at the request of construction industry leaders, investigators at the University of Washington developed a task-based protocol to measure 12 hour TWA exposures. They obtained Construction Program and Center funding to support worksite measurements. [Neitzel et al. 1999] • The investigators also studied workers' compensation claim records and documented the

high number of hearing loss claims filed by construction workers and the associated high costs to employers. [Daniell et al 1998]

- In 1998, with findings from the noise exposure and workers' compensation claim studies, the Washington State Building and Construction Trades Council and major employers created a labor-management organization called **BuildItSmart** to focus on providing industry-wide solutions to prevent noise-induced hearing loss. BuildItSmart was funded by the Construction Program and Center and the Washington State Department of Labor and Industries. [CDC 2000] It developed a three-pronged model based on the experience in British Columbia:
    - Develop and field test practical worksite prevention measures ("Block It, Move It, Fix It").
    - Incorporate safety and health training modules into all worker training courses. This training, which requires communication in noisy environments where workers frequently use hearing protection, led to the development of non-verbal communication such as signs and symbols.
    - Launch a portable audiometry testing program so that workers can move from employer to employer and still get annual hearing tests with a certification card. Several union-employer training centers purchased portable audiometry testing booths and enabled their staff to become certified audiometry testing technicians. Workers were tested and trained in hearing protection (including fit testing) during annual training. A quality control system and central database were established. Certification cards are issued to workers who have completed testing and training.
- In 1999, the University of Washington obtained a NIOSH RO1 grant to study hearing loss among construction apprentices. They documented significant hearing loss after short periods of construction employment. [Seixas et al. 2005]
- During 2000-2005, the BuildItSmart program, or parts of it, was gradually adopted in other parts of the country, including the OSHA National Training Institute and building trades in Massachusetts and California.

In 2005, the Washington State chapter of the Associated General Contractors (AGC) adopted an industry-wide hearing conservation program based on the model developed by BuildItSmart. University of Washington investigators received two NIOSH RO1 grants; one focused on intervention evaluation research with the AGC program, and the other focused on longitudinal follow-up of hearing loss. Another project focused on interventions to reduce noise exposures in highway work zones was included in the CPWR Construction Center consortium.

C) Outputs and Transfer

(For those outputs not specifically cited, see Appendix 2.1)

Exposure Characterization/ Methods Research

Exposure data for various trades and tasks have been presented and published in peer reviewed articles.[Kerr et al 2002] [Seixas et al 2001;Neitzel et al,1999]. Construction Program researchers produced 19 peer-reviewed journal articles and transferred research findings with 16 conference presentations and papers. In addition, supported researchers developed a series of plain language guides for ten different construction trades [Neitzel et al, 1999]. They provide information such as lists of tasks and tools in increasing order of average noise exposure and the percentage of times that workers doing the task should expect to wear HPDs. Worker and supervisor training materials were also developed. These publications have been made available via websites such as Elcosh, and the University of Washington. The Construction Center developed and disseminated one page “Hazard Alert” for construction noise to describe typical construction noise levels and to describe what workers need to know to protect themselves.

In 2005, Program researchers collected noise exposure data from power tools in collaboration with the University of Cincinnati and posted the data on a searchable website to disseminate the findings. [NIOSH 2001] Program researchers update and maintain the site. Intended to encourage tool buyers to buy quieter tools, it may also motivate tool manufacturers to design, build, and market quieter tools. The website receives about 300 hits per month.

Construction Program and Center research efforts on exposure to impulsive noise and development of new measurement instruments have been published and presented at national and International professional conferences. [Kardous et al. 2005]

Health Effects Research

The results of a longitudinal study of noise exposures and hearing loss were reported in 8 peer-reviewed journal articles and technical presentations. [Seixas et al, 2005;Neitzel et al 2005;Seixas et al, 2005; Seixas et al, 2004; Reeb-Whitaker et al 2004]. A website was also established to disseminate study results: http://staff.washington.edu/rneitzel/research.htm.

Engineering and Work Practice Interventions

We produced 8 peer-reviewed journal articles and 43 conference presentations and papers related to engineering and work practice interventions.

BuildItSmart developed a system of colored stickers to be applied to equipment and tools to warn workers about their probable noise risks. The noise categories are: green circle (safe), less than 85 dBA; yellow triangle (caution), 85 – 95 dBA; orange square (hazard), 95 – 105 dBA; and red octagon (danger), higher than 105 dBA [ELCOSH 2004] OSHA is exploring how to encourage adoption of this system.

Education, Training, and Guidelines

The Construction Program produced seven peer-reviewed journal articles, seven NIOSH publications and products, and 15 conference presentations and papers related to education and training. Staff and partners have made hundreds of presentations to scientific and industry meetings, have issued numerous reports and published dozens of papers in the scientific and industry literature. The most significant outputs include:

Between 2003 and 2005, visits to the NIOSH website’s noise topic page increased by 139%. Although we know little about these visits, this page includes a number of topics that are directly relevant to hearing loss and noise in construction. These results can be attributed to the availability of several different hearing loss products and the use of innovative web technologies, such as flash and dynamic content.

The construction web-based information system (“ElCosh”--http://www.cdc.gov/elcosh) has an entire section devoted to noise risk and noise prevention. [ELCOSH 2000]

The pilot study with carpenters produced a number of products including:

1) a training video designed to address barriers to wearing hearing protectors cited by construction workers

2) a training video designed to increase self-efficacy regarding hearing protector fit and use,

3) a multi-media CD designed to demonstrate the negative effects of tinnitus, and

4) a survey tool for assessing attitudes, beliefs, and behavioral intentions regarding hearing loss prevention. [Stephenson 1998]

In 2000, NIOSH, OSHA, and the Laborers Health and Safety Fund of North America co-sponsored a national conference on best practices for preventing hearing loss in the construction trades. The conference presentations are available in a proceedings document on line at: http://www.lhsfna.org/index.cfm?objectID=BC75435C-D56F-E6FA-936770051B4B44E1.

The Construction Program supported research on using a health promotion model to increase the use of hearing protection devices led to several peer-reviewed publications such as: “Use of Hearing Protection and Perceptions of Noise Exposure and Hearing Loss Among Construction Workers” along with training materials and videos.

Some highlights regarding use of specific Program-produced, peer-reviewed journal articles by other researchers are:

Lusk SL, Kerr MJ, Kauffman SA [1998] Use of hearing protection and perceptions of noise exposure and hearing loss among construction workers Am Ind Hyg Assoc J 1998 Jul; 59(7):466-470. (Cited by 25)

Lusk SL, Ronis DL, Hogan MM [1997]. Test of the health promotion model as a causal model of construction workers' use of hearing protection Res Nurs Health 1997 Jun; 20(3):183-194. (Cited by 25)

Neitzel R, Seixas N, Camp J, Yost M. [1999]. An Assessment of Occupational Noise Exposure in Four Construction Trades. AIHAJ (60) 807-817. (Cited by 23)

Henderson D, Hamernik, RP [1986]. Impulse noise: critical review. J Acoust Soc Am 80(2):569-584. (Cited by 25)

Lusk SL, Hong OS, Ronis DL, Eakin BL, Kerr MJ. [1999] Early-MR Effectiveness of an intervention to increase construction workers' use of hearing protection. Hum Factors 1999 Sep; 41(3):487-494. (Cited by 12)

Seixas N, Neitzel R, Camp J, Yost M. [2001]. Noise Exposure among Construction Electricians. AIHAJ *62*:55, 615-621, 2001. (Cited by 11)

Reeb-Whitaker CK, Seixas NS, Sheppard L, Neitzel R [2004]. Accuracy of task recall for epidemiological exposure assessment to construction noise. Occup Environ Med 61(2):35-42. (Cited by 6)

Seixas N, Goldman B, Sheppard L, Neitzel R, Norton S, Kujawa S [2005]. Prospective noise induced changes to hearing among construction industry apprentices. Occup Environ Med 62:309–317. (Cited by 5)

Seixas N, Kujawa S, Norton S, Sheppard L, Neitzel R, Slee A. [2004]. Predictors of hearing threshold levels and distortion product otoacoustic emissions among noise exposed young adults. Occup Environ Med 2004;61(11):899-907. (Cited by 5)

D) Intermediate and End Outcomes

Exposure Characterization/ Methods Research

A cooperative research and development agreement (CRADA) with Larson-Davis Inc. resulted in manufacture of a new instrument based on Program software algorithms involving impulsive noise common in construction. The new instrument (Sound Level Meter 831) will allow users to collect data to support the development of an occupational damage risk criterion for impulse noise. No instrument performing this task is currently available.

Education, Training, and Guidelines

OSHA issued an Advance Notice of Proposed Rulemaking (ANPR) to amend the current OSHA hearing conservation standard for the construction industry (29 CFR 1926.52). The ANPR extensively cited work by NIOSH and other participants in the NIOSH Construction Program [OSHA 2002]. OSHA requested that Construction Program scientists attend stakeholder meetings and provide technical briefings on applying current technologies to an updated hearing loss prevention standard for the construction industry. OSHA is adopting the noise labeling system for tools and equipment developed by BuildItSmart [LHSFNA 2002].

Construction Program researchers participated in efforts to design an American National Standards Institute (ANSI) standard for hearing loss prevention in construction (ANSI A10.46) which OSHA could use as a rulemaking template. The ANSI committee used the powered handtools database and exposure characterization data generated by the Construction Program to develop 8-hour time averaged OELs for the recently-issued construction standard [ANSI 2007].

Twenty-five authors have cited the health promotion model research and the 2003 American Academy of Audiology Position Statement on Preventing Noise Induced Hearing Loss referenced it. In addition, the American Industrial Hygiene Association (AIHA) converted the health promotion model video and training materials into a training product sold by the organization to safety and health professionals.

NIOSH recommendations regarding hearing protector use received national television coverage in 2003 when a Construction Program researcher appeared on an episode of “This Old House.” This appearance gave the problem of noise-induced hearing loss from power tools and NIOSH’s role in prevention national visibility.

A UBC pilot study tested Construction Program training methods at its International Training Center and expressed a commitment to adopt the training method developed by Construction Program researchers at their 150 training centers which service their 500,000 membership.

In 2003 and 2004, the U.S. Navy paid nearly $13 million in worker compensation for hearing loss to civilian employees. Approximately 18% of Navy civilian workers had a standard threshold shift attributed by occupational safety and health staff to improper use of hearing protectors. The Navy asked NIOSH to collaborate on a field study to determine if Construction Program training methods developed for construction workers could reduce the incidence of occupational hearing loss among Navy shipyard workers, given some similarities in tasks. The Navy is using a NIOSH-developed hearing protector fit test system and training video in conjunction with this effort.

Numerous construction contractors in Western Washington state, 11 Western Washington apprenticeship training programs, and the Associated General Contractors of Western Washington have incorporated the training materials developed as a result of a Construction Program study into their training programs.

Construction Center research has been reported in various construction union articles such as “Construction Noise Can Be Silencing,” *UA Journal,* July 1997, 15 and “Noise: The Not-So-New-Quiet Hazard.” *IBEW Journal,* May 1997.

E) External Factors

The nature of hearing loss as an occupational illness presents both a challenge and an opportunity for the Program. Although hearing loss is permanent, in most cases it has a gradual onset and sometimes is not considered serious enough to warrant aggressive preventive actions (and the research that would identify and validate preventive actions). The gradual onset of hearing loss also works against employers’ motivation to overcome economic barriers to investing in quieter equipment, improved work practices, or better use of hearing protectors.

It would be hard to find a risk in occupational health that has been better characterized, affects more workers, and for which less has been done in terms of prevention. The exception to this is Washington State where there is a state Occupational Safety and Health Regulation for noise in construction and workers’ compensation disability coverage for hearing loss. Without either an OSHA requirement or having to pay for hearing loss, conditions in the rest of the country offer insufficient penalties or incentives to advance hearing conservation. While OSHA has not yet reached the proposal stage for a nation-wide regulation, so a nationwide rule is several years away.

The nature of the construction industry, with temporary employment, is a major impediment to implementing hearing conservation. Where hearing conservation programs have been most effective, in British Columbia and Sweden, they have come from implementation of industry-wide programs with portability from employer to employer. [Schneider et al 1995] This too is a major challenge in the U.S. given the fragmented nature of construction.

Two recent events in the regulation area may act as external factors on the issue and the Construction Program:

- Effective July 1, 2007, New York City's Noise Code will require construction projects to apply *best available technology* in terms of construction machinery and equipment with the lowest noise available in the market. [NYC 2007] This represents a major advancement over existing noise control ordinances, which largely limit the time periods when noisy work can be performed in urban areas.

- On March 12, 2007, the International Safety Equipment Association petitioned OSHA to change the exposure limits for noise in construction from 90 dbl to 85 dbl, and to reduce the doubling rate from 5 dbl to 3 dbl.

F) What's Ahead?

The etiology of noise-induced hearing loss is well documented and construction noise exposure sources are well characterized. There is, however, a great need for continued pressure to promote and implement noise exposure prevention practices. Because progress on this front is slow and cumbersome, it is a frustrating task. The Construction Program developed a draft strategic goal for noise and hearing loss that included draft intermediate goals such as developing models for "portable" hearing conservation and working with tool manufacturers to develop noise control approaches. In addition, noise and hearing loss was selected by the NORA Construction Sector Council as a top health hazard issue to focus on in the years ahead.

Ongoing research includes:

Exposure Characterization/Methods Research
University of Washington investigators are conducting a longitudinal follow-up of hearing loss for a group of workers who have been followed since they were apprentices.

Currently, there are no universally acceptable methods to measure impulsive noise nor are there criteria to evaluate the potential for hearing loss from such exposure. The Construction Program is developing new instruments, examining the effectiveness of hearing protectors, revising measuring standards, and participating in the establishment of a national occupational damage risk criterion to characterize the effect of impulsive noise on hearing.

Engineering and Work Practice Interventions

Construction Program supported University of Washington investigators are also engaged in intervention evaluation research with and AGC industry-wide hearing conservation program. Another Construction Center project focuses on interventions to reduce noise exposures during construction in highway work zones.

Virginia Tech investigators are studying back-up alarms on vehicles at construction sites to determine the best interface between such alarms and hearing protection, so that one does not cancel out the other.

The Construction Program powered hand tool database containing 128 tools aims to add 75 new tools per year over the next 3 years and to develop and publish a “Hazard Alert on Noise Emissions from Powered Hand Tools.”

The Construction Program will partner with the NIOSH Noise Control Program on efforts to establish a consortium of powered hand tool manufacturers, noise control experts, government agencies (OSHA and EPA), labor organizations, and insurance carriers to identify and solve noise emission concerns on the more than 3500 tools on the market.

Education, Training and Guidelines

The Construction Program will revise and publish its “Noise Control Compendium” as an interactive technical document.

The Construction Program is developing a technical document on impulsive noise measurements in the workplace.

Existing efforts will continue through standards setting bodies to encourage the widespread use of noise labeling for construction machinery and equipment that produce hazardous levels of noise. These efforts will motivate “buy quiet” and “design quiet” programs, and the labeling of machinery and equipment producing greater than 85 dBA sound power.

The Construction Program plans to develop standards for impulsive noise measurement for hearing protection devices.

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Sub goal 2.2 Lead Exposure and Various Health Effects

A) Issue

While the use of lead has been curtailed in recent years, construction workers continue to experience exposures to lead "in place" from earlier usage. Plumbers, painters, electricians and remediation workers can be exposed in residential, commercial and infrastructure repair settings. Welding or cutting on lead-painted metal surfaces, abrasive blasting of bridges, or demolition of lead-containing materials are examples of tasks that can cause exposures.

Lead poisoning is an historically-important occupational health problem across a number of industry sectors and NIOSH activities on lead pre-date the Construction Program. NIOSH recommended a standard for lead in 1978 and OSHA promulgated a standard for lead for general industry in 1979 that included a Permissible Exposure Limit (PEL) of 50 µg/m3 and an acceptable blood-lead-level (BLL) of 40 µg/dL. Unfortunately, construction was excluded from coverage under the new rule. The outdated legal exposure limit in effect for construction was four times higher with no blood-lead testing provisions. NIOSH funded a number of state level surveillance programs in 1981, and these programs, augmented in 1988, provided reports that construction-related industries accounted for the highest proportion (30.4%) of workers with BLLs greater than 70 ug/dL [CDC 1987]. Other investigators also reported high exposures and high blood leads among construction workers in New York [Fischbein et al. l978, l984] as well as in New Jersey [Mehta 1990] and California [Waller et al. l992] in the following years.

Lead exposure to construction workers was identified as an important issue in the early national Construction Conferences held in conjunction with the creation of the NIOSH Construction Program in 1990. In 1990, NIOSH set a national goal of eliminating exposures that result in worker having blood lead concentrations greater than 25 ug/dL. In response, OSHA announced later that year that it would begin to develop a comprehensive rule for lead in construction. Increasing awareness about the problem of childhood lead poisoning led to guidance from the U.S. Housing and Urban Development Department (HUD) and to passage of Public Law 102-550 - The Housing and Community Development Act of 1992. Title X of this Act, "The Residential Lead-Based Paint Hazard Reduction Act of 1992" required OSHA to issue an interim final rule for lead in construction within 180 days, and it required NIOSH to investigate (1) the States surveillance and intervention capability for lead, (2) lead abatement control methods and work practices to prevent hazardous lead exposures, (3) health effects of occupational lead exposures, (4) high risk occupational settings, and (5) the potential lead exposures and risks to janitorial and custodial workers.
Accordingly, the Construction Program focused on a number of key activities during the early 1990's such as providing information on health effects, exposure

methods and data, and controls to OSHA, EPA, and HUD to support rulemaking, and responding to Congressional mandates.

B) Activities

Hazard Surveillance

The Construction Program collaborates with NIOSH researchers to use state-based surveillance programs such as the Adult Blood Lead Epidemiology and Surveillance (ABLES) program. ABLES created a standardized national reporting system for laboratories to report adult BLLs. The ABLES program has grown to 37 states,2 and is the national data source used to track the Healthy People 2010 lead poisoning objective, and aims to help the States meet this objective. Additional supported surveillance efforts include the following:

- Beginning in 1990, the Connecticut Road Industry Surveillance Project (CRISP) used a centralized, statewide surveillance system to monitor blood lead levels in bridge workers (based at CT DPH) [Hammond et al. 1994]. Data from 90 bridge projects from 1991 to 1995 and approximately 2,000 workers were evaluated.

- Construction Program researchers and the New Jersey Department of Health and Senior Services (DHSS) conducted a surveillance study in 1993 and 1994 involving the voluntary participation of 46 construction workers' families. BLL testing of young children indicated that the workers' children, particularly those under age six, were at greater risk of having elevated BLLs (≥ 10 µg/dL) than children in the general population.

Health Effects Research

The Construction Program provided support for a study evaluating the effect of exposures to more than one neurotoxicant (e.g. lead, solvents) during a job, to determine if these mixed exposures may create quantitative as well as qualitative neurotoxic effects that differ from those occurring with lead or solvent exposure alone. Neurobehavioral tests of cognition, sensory function, and mood were compared between four groups of construction workers. Based on exposure monitoring, the construction workers were classified into four exposure groups: lead exposed, solvent exposed, lead/solvent exposed, and unexposed controls. Participants were members of the International Association of Bridge, Structural and Ornamental Iron Workers or International Brotherhood of Painters and Allied Trades (IBPAT). Findings indicated that bone lead was associated with slower speed of processing while exposure to lead and/or solvents reduced efficiency of verbal learning [Fiedler 1998].

[2] Alabama, Alaska, Arizona, California, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Washington, Wisconsin, Wyoming.

Methods Development

Lead containing materials in place cannot be identified with the naked eye or building records. Construction Program researchers received requests from industrial hygienists, risk assessors, medical officers, and other public health professionals to develop field-portable sampling and analytical methods for workplace lead for on-site application in construction. A multifaceted approach was used to develop and evaluate portable methods in the lab and field for the measurement of lead in several media - workplace air, surface dust, and blood samples. This multi-year effort involved the collaboration of number of partners from other divisions and agencies, academia, and private industry. Screening methods for lead in workplace air and surface dust were investigated and evaluated [Song et al. 2001; Ashley et al. 2002]. Portable quantitative methods based on electroanalysis were evaluated and validated for applications in the determination of lead in air, surface dust and blood [Morley et al. 1999; Ashley et al. 2001; Taylor et al. 2004].

Exposure Characterization

Construction Program researchers systematically investigated exposures associated with lead exposures, including special attention to the exposures associated with different residential lead abatement techniques such as use of heat guns and power sanding. Other important tasks evaluated include abrasive blasting and torch-cutting of painted steel surfaces.

Exposure characterization efforts also addressed the issue of “take-home” exposure, an important issue for lead given the vulnerability of children to lead poisoning. The ABLES program had identified this linkage in 1991 and in 1992, the U.S. Congress passed the Workers' Family Protection Act (Public Law 102-522) [29 USC 671]. This Act requested NIOSH to "evaluate the potential for, prevalence of, and issues related to the contamination of workers' homes with hazardous chemicals and substances... transported from the workplaces of such workers." In response to these findings, Construction Program Researchers conducted a series of exposure assessment studies to measure workers’ blood lead levels; personal breathing zone airborne lead exposures; and lead contamination on skin, clothing, in automobiles, and homes of lead-exposed construction workers [NIOSH 1995; Piacitelli et al. 1997]. This research identified an increased presence of lead contamination in households and elevated blood lead levels in children of construction workers [Whelan et al. 1997].

Construction Program supported researchers in Washington State evaluated lead exposures and worker protection of residential painting contractors via their Safety and Health Assessment and Research for Prevention (SHARP) program. This effort included telephone surveys and worker exposure evaluations of five homes with lead-based paint activities [SHARP 1995].

Intervention Development and Evaluation
Exposure characterization studies typically involved some development or evaluation of interventions to reduce exposures. Construction Program exposure evaluations of residential and steel structure lead abatement options included development of recommendations for worker protection. Residential evaluations investigated the use of alternate abatement processes (enclosure, encapsulation, and replacement), wet methods, vacuum power tools, dilution ventilation, and administrative controls. Researchers have assessed the efficacy of controls designed to protect workers from exposure to lead during structural steel rehabilitation projects. In addition to the residential controls, steel structure evaluations included safer surface preparation alternatives (overcoating, chemical stripping, wet blasting), engineering controls to the extent feasible (isolation, local exhaust, general dilution ventilation, and automated abrasive blasting equipment), and approaches for assessing lead exposures, control of these exposures, and clinical evaluation and management of ironworkers.

The CRISP study was a 5-year demonstration project to reduce lead poisoning in workers engaged in bridge construction work involving lead-based paint. It designed model contract language including detailed medical and environmental specifications (industrial hygiene monitoring, personal and ambient air sampling for lead, minimum standards for protective equipment, and standardized comprehensive medical monitoring using the CRISP protocol) which was then applied to and evaluated on several bridge renovation and maintenance projects. This demonstration project was instrumental in lowering bridge worker BLLs [Vork et al. 2001; CDC 1995a]. The workgroup for the project developed twelve recommendations including one suggesting that the U.S. Department of Transportation require comprehensive measures to protect workers and the environment against hazardous lead exposures [Erville 1995]. There were many partners including Yale University School of Medicine, Connecticut Department of Public Health, and the Mt. Siani School of Medicine [Vork et al. 2001].

The Construction Center used a two-phase approach to evaluate and continuously improve upon model specification language drafted in 1993. First, the efficacy of the Model Specifications for the Protection of Workers from Lead on Steel Structures was evaluated at NASA Lewis Research Center (NLRC), now NASA Glenn Research Center, on a small lead abatement project. Second, updated specification language was then used as part of a site-based evaluation conducted during rehabilitation of the Blue Water Bridge (Michigan). Participatory research methods were used to seek the active involvement and input of all parties necessary for changing conditions in construction, including labor, owners, contractors and government agencies that regulate and/or influence occupational health and safety. In 1999, a peer review committee reviewed both phases of the Model Specifications project resulting in the current revised 2002 edition of the Model Specifications [CPWR 2002].

The Construction Center established partnerships for this project which included:

- The Mt. Sinai School of Medicine
- The Ohio Building and Construction Trades Council (OH BCTC)
- The Cleveland BCTC with support from the International Union of Painters and Allied Trades (IUPAT) District Council (D.C.) 6 in Cleveland
- The Georgia BCTC
- The Alliance to End Childhood Lead Poisoning
- The Federal Highway Administration

Cooperation and Collaboration
A broad coalition works with the Program to reduce occupational lead exposures in construction, including the following main partners: (1) OSHA--National Emphasis Program to reduce occupational lead exposures; (2) the Council of State and Territorial Epidemiologists - lead surveillance initiatives; (3) a federal lead-based paint task force; 5) National Center for Environmental Health task force on non-residential environmental lead source; 6) NCEH National Electronic Disease Surveillance System (NEDSS) partnership for standardized surveillance; and 7) the Association of Occupational and Environmental Clinics (AOEC) Clinical BLL guidelines committee.

Construction Program researchers have participated as technical advisors and reviewers to the EPA, HUD, the National Center for Lead-Safe Housing, and the Washington Department of Labor and Industries in development of guidelines, policy, and regulations.

The Program supported the training of lead-based paint abatement workers in New York as well as two research grants that related to lead exposed construction workers. These research grants included an evaluation of controls for protecting lead exposed workers and elevated BBLs in the Iowa construction industry [NIOSH 1994].

C) Outputs and Transfer
(See Appendix I Section 2.2 for complete listing of outputs and transfers)

Hazard Surveillance
ABLES surveillance findings are reported quarterly in CDC's Morbidity and Mortality Weekly Report, and information on the ABLES program is provided on a webpage http://www.cdc.gov/niosh/topics/ABLES/ables-description.html, a listserv ABLES@listserv.cdc.gov, and meets once a year in conjunction with the Annual Conference of the Council of State and Territorial Epidemiologists. In addition, various states produce reports summarizing findings and trends in their state. For example, a New Jersey Health Department Occupational Health Surveillance Special Issue on Lead (http://www.state.nj.us/health/eoh/survweb/apr02.pdf)

Health Effects Research

Construction Program researchers authored three peer-reviewed journal articles and six book chapters on the effects of exposure to more than one neurotoxicant. Google Scholar shows 27 exact matches of professional publications citing the lead neurobehavioral evaluations.

Methods Development

Products resulting from this multi-year endeavor included 37 peer-reviewed publications, book chapters, and trade journal articles; nine NIOSH analytical methods; 17 voluntary consensus standards; and a commercialized patent [Esswein et al. 2001]. Construction researchers have made seven presentations to report on these results to EPA, the Construction Safety Council, and professional symposiums. In response to the National Technology Transfer and Advancement Act of 1995 (NTTAA), Construction researchers and numerous other stakeholders contributed to the development of analytical consensus standards to qualitatively and quantitatively determine the presence of lead on construction worksites [ASTM 2001, 2003]. Construction staff also participated in the Interagency Lead-based Paint Task Force (formed by EPA and HUD) which initiated efforts to improve the measurement of lead in various matrices [EPA 1992]. Numerous recommendations have been made to EPA on field-portable methodologies for sampling and analysis of lead in environmental samples (workplace air, surface dust) and blood [NIOSH 2006].

In 2002, Construction Program Researchers developed and patented a colorimetric wipe, Complete Safety Management Tool for Lead Researchers. The method quickly and easily detects the presence of lead on skin, including the face, and surfaces such as tables, shoes, steering wheels, safety glasses and windowsills. The lead wipe technology was licensed by SKC Inc. and is sold commercially as Full Disclosure Lead Wipes [Dietrich 2002].

In November 2006, Construction Program staff conducted training at the University of Iowa's rural health facility in Sigourney, Iowa. Staff trained technicians, professors, and two nurses in the operation of the portable blood lead analyzer and the portable environmental lead device. The University of Iowa is using these instruments to gather lead exposure data in Keokuk County, Iowa, as part of their ongoing rural health study.

Exposure Characterization

Construction Program and Center researchers authored eight peer-reviewed journal articles, presented 31 times at professional safety and health conferences, and participated nine times as expert lead technical advisor/reviewer to EPA and HUD on guideline documents, proposed rulemaking, and national lead training courses. From 1978 to the present, the Construction Program has conducted 10 health hazard evaluations concerning construction activities including abatement of lead-based paint and abrasive blasting [NIOSH 1997a]. These evaluations initiated numerous projects In 1991, Construction Program researchers contributed findings from these evaluations and were contributing authors on a NIOSH Alert addressing construction and lead poisoning (revised in 1992) [NIOSH 1991, 1992a]. Also in 1991, NIOSH issued a report jointly with OSHA, Working with Lead in the Construction Industry [OSHA/NIOSH 1991]. The health hazard evaluations concerning occupational exposures to lead in construction and other sectors were compiled into a comprehensive publication [NIOSH 2001].

In 1995, in response to the Worker Family Protection Act, NIOSH published a report on lead and other "take-home" toxins in a Report to Congress, produced a synopsis of this report, and produced an update on lead poisoning in children [NIOSH 1995, 1997b,c]. Beginning in 1994, a task force reviewed the NIOSH report and made recommendations to Congress for additional investigation into the take-home lead hazard [NIOSH 2002]. The NIOSH 1995 Report to Congress on the Workers' Home Contamination Study resulting from findings from Construction Program and Center research made specific recommendations for improving hygiene practices at construction work sites. These findings were also provided in comments to proposed rulemaking by OSHA, EPA, and HUD concerning lead in construction activities.

A separate report for policymakers titled: "Protecting Workers Exposed to Lead-Based Paint Hazards: A Report to Congress" was published in 1997. The report provided information on the magnitude and variability of exposures associated with residential lead and structural steel lead abatement and summarized exposure control recommendations [NIOSH 1997].

A Construction Program researcher authored the *Worker Protection chapter in: Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*, U.S. Department of Housing and Urban Development [HUD 1995]. These guidelines apply to all federally-sponsored or -funded lead abatement or lead hazard reduction work in the U.S. and U.S. territories. In response to Housing and Community Development Act, the Construction Program provided Congress with a report addressing not only the mandated topics, but also other issues such as lead exposures to workers families [NIOSH 1997d]. Construction Program staff provided input to HUD and their publication concerning lead paint safety [HUD 2001].

The Construction Center has provided research data and technical support to weigh in on lead rule-making to both OSHA and EPA [BCTD 1995, 1997, 2001, 2005, 2006].

Intervention Development and Evaluation
Program researchers produced over 20 reports and journal articles that evaluated residential and steel structure lead abatement options for worker protection from lead exposures. For example, we recommended wet methods for

residential abatement after documenting significantly-lower exposures for wet versus dry methods. We also wrote about our evaluation of automated abrasive blasting equipment on steel structures to determine their feasibility for reducing lead dust [NIOSH 1993, 1999]. We also assessed paint removal prior to oxy-acetylene torch cutting of steel and encapsulation of rivets prior to their removal and produced a booklet for contractors and workers [Clark and Goldberg 1998].

We sent 380 copies of the Model Specifications to state and local building trades councils and unions representing ironworkers, painters, laborers and other crafts. They provided copies to their local affiliated unions.

Construction Center researchers participated in two Society for Occupational and Environmental Health (SOEH) work groups and contributed as an author to the document: *Protecting Workers and Their Communities from Lead Hazards: A Guide for Protective Work Practices and Effective Worker Training [*SOEH 1993]. The preamble to OSHA and EPA proposed lead rules references this document as a key resource in the development of standards.

In 1997 and 2001, the International Union of Painters and Allied Trades worked with the Construction Center in developing and delivering a class entitled *Science, Air Monitoring, Written Programs and Testing Devices*. It used the *Model Specifications* and instructed journeymen painters, apprenticeship instructors and union representatives on how to monitor and control lead hazards.

In 1994, California developed a lead safety manual for painting contractors [CDHS 1998; Materna et al. 2002; Scholz et al. 2002].

D) Intermediate Outcomes

Hazard Surveillance

Several states have used Construction Program support to develop surveillance outputs addressing construction. They include the following:

- New York education efforts targeting construction workers about lead hazards
    1. ABLES data from 2000-2005 indicating that bridge, highway construction contractors, and residential painters are at risk for exposure to high levels of lead are on the Bureau of Occupational Health (BOH) web page [NYS 2006]. Additionally, the BOH has distributed 150 Lead on the Job: A Guide for Employers brochures to heavy metals registry construction companies with a record of an employee with a Blood Lead Level (BLL) of 25 mcg/dL or over.
    2. BOH staff have sent mailings to approximately 500 highway construction companies and New York State Department of Transportation and Thruway subcontractors regarding lead, hazards and methods to control exposure.
    3. BOH has performed over 20 outreach and educational programs to contractors reaching over 300 people.
- New Jersey developed educational methods and materials addressing lead exposure in construction and lead paint hazards. Additionally, all New Jersey workplaces in the ABLES database are evaluated for intervention activities conducted by the State and OSHA. Intervention impact is determined by evaluating reductions in the number of reports and average BLLs.
- Wisconsin calls any employer who has an employee with a BLL greater than 40 µg/dL to determine if the employee is exposed to lead. The employer is sent a questionnaire to complete and follow-up is conducted to reduce the employee's lead level. If the employer has under 250 employees, they are also given information about the services of OSHA Consultation.

Lead is the health hazard with the most established surveillance infrastructure, and it is used to support state and OSHA interventions. ABLES data became the first occupational health condition reported regularly in the MMWR. Cases identified through ABLES surveillance are used to target high-risk industries such as construction for intervention and are referred, when necessary, to State or Federal OSHA programs for consultation or enforcement. Routine ABLES state interventions to prevent lead over-exposures include: (1) conducting follow-up interviews with physicians, employers, and workers; (2) investigating work sites; (3) providing technical assistance.

ABLES data have been used to identify groups at high risk of lead poisoning (e.g. Bridge demolition workers [CDC 1989]) and as a resource for evaluating the effectiveness of interventions (e.g. CRISP).

OSHA has used Construction Program ABLES data, methods development, and worker exposure information for its "lookback" review of the construction lead standard, 29 CFR 1926.62 [NIOSH 2005]. To make the ABLES data more useful to OSHA for targeting lead inspections, a MOU to share the ABLES data with OSHA was completed in August 2006.

Relying substantially on Construction Program and Center guidance, as of 2005, in the Steel Structures Painting Council's Painting Contractor Certification Program designed to assess the capabilities of contractors to protect worker health and safety and the environment, there is a requirement to submit a copy of the company's written Safety and Health Plan for Hazardous Paint Removal work. At a minimum, the plan should meet applicable OSHA requirements, as well as relevant NIOSH Guidelines. Likewise, their Thermal Spray (Metallizing) Contractor Certification Program requires candidates to operate a formal program to acquire information from recognized sources such as OSHA and NIOSH [SSPC 2007a,b].

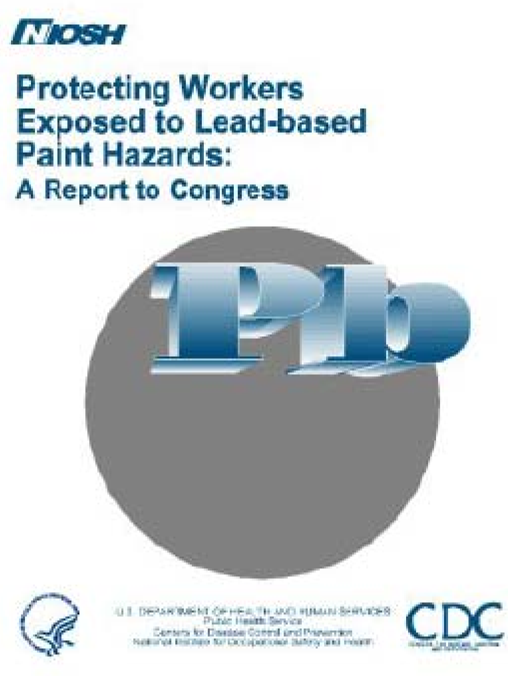
Methods Development

One of the recommendations of the Interagency Lead-based Paint Task Force was to establish an intergovernmental agency laboratory accreditation program for the analysis of lead in paint, dust, and soil [EPA 1992]. Based upon this recommendation, the National Lead Laboratory Accreditation Program (NLLAP) was created to ensure that laboratories showed consistent and quality results in their analysis of lead samples.

Recommendations on field-portable methodologies for sampling and analysis of lead in environmental samples have influenced EPA regulations on renovation and remodeling [40 CFR Part 745].

Exposure Characterization

As a result of "take-home" toxin study findings, Congress adopted Amendments to the 1992 Housing and Community Development Act (Public Law 102-550) in 1987 and 1988 which required HUD to perform a LBP abatement demonstration program. At the request of HUD, NIOSH evaluated worker protection measures and lead exposures during the HUD demonstration project in 1989 and 1990 [NIOSH 1992]. The 1997 NIOSH Report to Congress and NIOSH HHE reports on lead hazards during home renovation are cited as reference materials by Lead-Safe USA, the web site of the National Association of the Remodeling Industry, www.Leadsafeusa.com [NARI 2007].



HUD provided a “Report to Congress” which highlighted work from numerous federal agencies, including CDC and the Construction Program, in response to the Housing and Community Development Act of 1992 and its requirements of these agencies [HUD 1997].

In the preamble to its 1992 Lead in Construction Standard, OSHA cited the Construction Program HHE data and specifically findings of the evaluation of the HUD Lead-Based Paint Demonstration Project (1) in Section 2 - Key Issues [58 Fed. Reg. 26590(1993)]. In 1993, OSHA provided new guidance to its compliance officers regarding evaluating lead hazards at construction sites [29 CFR 1926.62].

A number of states have used Construction program and Center data and lead information in their own public health programs to reduce lead exposures in construction workers and their families, several examples include:

- The California Occupational Lead Poisoning Prevention Program provides construction information on lead training, blood lead information, and journal articles concerning painters/remodeling contractors [CDHS 2007; Materna et al. 2002; Harrington et al. 2004].
- The Massachusetts Department of Public Health, Division of Occupational Safety, have developed education materials addressing lead hazards and their control in the construction industry [MDOS 2006].

The American Society for Testing and Materials (ASTM) published a paper based on a Construction Program HHE report: An Evaluation of Airborne and

Surface Lead Concentrations from Preliminary Cleaning of a Building Contaminated with Deteriorated Lead-Based Paint. [Sussell et al.1995].

Intervention Development and Evaluation

HUD and EPA updated and produced work practice guidelines for construction workers and homeowners using Construction Program technical input and reports. For example, the Construction Program evaluation of lead-base paint hazard control methodologies was used in developing HUD guidelines, which were then used by EPA to develop draft technical specifications for renovation, repair, and painting activities. EPA also used the guidelines for development of a model training and certification program for training purposes under HUD's Lead Safe Housing Rule.

Construction Center's Model Specifications project has been used throughout a number of state-based departments and organizations.

- The project actively involved state building trades councils in reaching out to construction workers, their unions, and state and federal agencies within their states who are responsible for overseeing construction work or protecting worker health.
- State transportation agencies including New York, New Jersey, Michigan, and Maryland, used the Model Specifications in preparing and updating their job specifications governing lead work.
- The Construction Center's specifications and publications are a valuable resource for state health departments who often track elevated blood lead levels and may intervene when increased blood lead levels surface.
- Michigan and Missouri Labor Departments used the Model Specifications for lead poisoning prevention activities within their state. The Michigan Department of Labor and the Michigan Department of Transportation implemented elements of the Model Specifications on the Blue Water Bridge Project. The Missouri Department of Labor and Industrial Relations prepared a Missouri Contractors Guide for Lead Abatement, which included copies of the Model Specifications. Copies of the Guide were distributed throughout the state and are posted on several state web sites.
- In 1997, Construction Center's Model Specifications were described as a resource for worker protection in the National Cooperative Highway Research Program's Synthesis of Highway Practice 251 [NCHRP 1997].
- The Federal Highway Administration distributed copies of the Construction Center Model Specifications to state highway agencies throughout the U.S. and encouraged their use when preparing job specifications for lead painted bridges and overpasses [Willett 1993].
- Using information from the Construction Center findings, the NYCDOT incorporated aspects of findings into their specifications for lead control programs for bridge rehabilitation and demolition work, and Ironworker Locals 40 and 361 used materials developed for their training programs.

E) External factors

Due to changes in national coding systems (SIC to NAICS), and differences among state BLL reporting requirements, it is difficult to identify trends in construction BLLs. A recent analysis by NIOSH has identified specific categories of construction workers with elevated BLLs above 25 ug/dL and 40 ug/dL. Those include painters, bridge and tunnel workers, and workers involved in lead paint removal.

There were several important developments in the 1990s which may have impacted blood lead level trends among construction workers, making it hard to assess directly what impact the Construction Program's research alone may have had on reducing blood leads. Chief among these are:

- The Lead Exposure Reduction Act of 1992 (or Title X) which directed several agencies including OSHA, EPA, NIOSH and HUD to develop regulations and research initiatives aimed at preventing lead exposure to the public and lead contamination of the environment.
- Highway Funding. Beginning with the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 and continuing though out the 90s, billions of dollars were invested in restoration of thousands of lead painted bridges and elevated overpasses. The resulting increase in the number of construction workers exposed to lead during work on these projects undoubtedly led to increased numbers of elevated blood leads.
- EPA and OSHA lead standards. In 1993, OSHA published the Interim Final Rule – Lead Exposure in Construction (29 CFR 1926.62). Until this time, there was no lead standard in place for construction, only a permissible exposure limit (PEL) of 200 ug/m3 – four times the current PEL of 50 ug/m3. The standard also put in place requirements for exposure assessment, use of engineering controls, hygiene facilities, biological monitoring and a medical removal protection program. Given that the timing of this standard and our research initiatives were so close together, certainly, the OSHA requirements played an extremely important role in catalyzing greater protection of construction workers from lead. Owners, contractors and other groups were also more motivated to work with us on these projects given their interest in finding ways to comply with the new standard. In addition, OSHA initiated a Special Emphasis Program for lead on March 11, 1996, which resulted in increased inspections of construction projects involving lead exposure.
- EPA was directed under Title X to develop training and work practice standards for work involving lead paint on bridges and superstructures. Although EPA has yet to comply with that directive, several states including New Jersey, Virginia, Maryland and Missouri have enacted standards for de-leading of these structures. This development has likely increased attention to worker protection during lead paint removal on bridges and superstructures.

F) What's Ahead?

Since 2001, ABLES has collected individual blood lead data from each participating state. The data set is now analyzed by NIOSH staff and made available for public use, including the Construction Program and its stakeholders.

Construction Program researchers are evaluating the color-changing lead detection hand wipe method to determine if wipes could effectively serve as a feedback and exposure assessment tool that helps workers exposed to lead improve their hand washing practices. Comparison of feedback from companies that do and do not use the lead detection wipes will reveal (a) what conditions may facilitate effective use of the hand wipes, and (b) what conditions have been limiting the use of the hand wipes, (c) what resources (training, funding, work setting) may be needed for the effective use of the hand wipes.

In developing draft strategic goals, the Construction Program developed a draft intermediate goal to: "Demonstrate that elevated blood leads among construction workers can be reduced via a focused surveillance and intervention program". Because both a rigorous OSHA standard and an existing health surveillance system involving reporting of elevated blood leads is in place, this provides an opportunity to work with state partners on a demonstration project to focus technical assistance, training, and surveillance resources to obtain an ambitious reduction in the occurrence of elevated blood leads among construction workers. We will be revisiting this draft goal with stakeholders as part of our NORA Sector process.

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Subgoal 2.3 Silica Exposures and Silicosis

A) Issue

Silicosis is a debilitating and sometimes fatal lung disease resulting from breathing microscopic particles of crystalline silica. Respirable crystalline silica (RCS) exposure occurs in a wide variety of industries and occupations, including the construction industry and construction related occupations, and is associated with silicosis, lung cancer, and other diseases. In the construction sector the most common exposures involve the disruption of materials containing crystalline silica including:

- Chipping, hammering, and drilling of rock,
- Crushing, loading, hauling, and dumping of rock,
- Abrasive blasting using silica sand as the abrasive,
- Abrasive blasting of concrete regardless of the abrasive used,
- Sawing, hammering, drilling, grinding, and chipping of concrete or masonry,
- Demolition of concrete and masonry structures,
- Dry sweeping or pressurized air blowing of concrete, rock, or sand dust.

Our surveillance system currently captures approximately 200 silicosis-related deaths annually in U.S. workers with an unknown number going unreported or undiagnosed.

NIOSH has been active on silica research issues since the early 1970s. In 1974, NIOSH published criteria for a recommended standard. In 1988, NIOSH testimony to OSHA recommended that crystalline silica be labeled a potential occupational carcinogen. Occupational lung disease was one of the problems identified as the NIOSH Construction Program got started in 1990 and a project to understand silica exposure in the construction industry was one of the original projects targeted by NIOSH Construction Program researchers. Work was also coordinated with other interested NIOSH researchers.

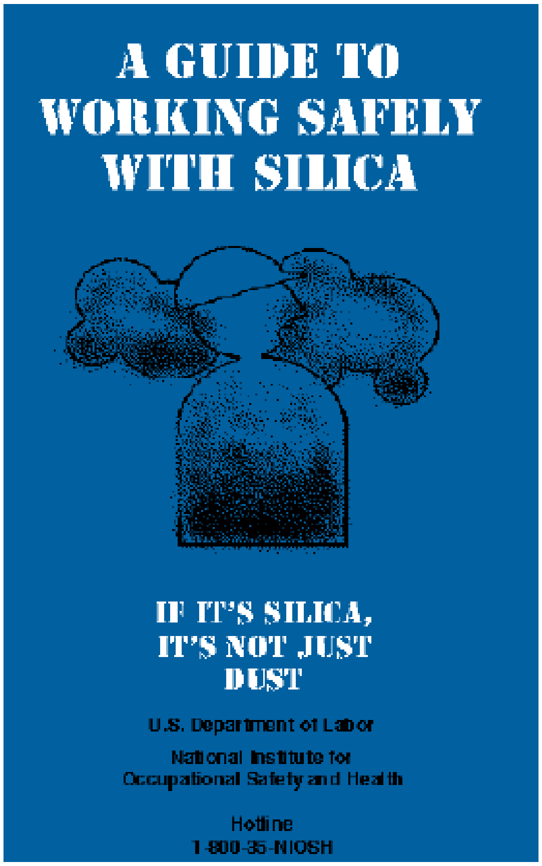
Surveillance findings indicated for the years 1985-1990 the construction industry was the industrial sector most frequently recorded on death certificates (10.8%) documenting deaths related to silicosis. These data were published in The Work-Related Lung Disease Report series [NIOSH, 1994].

B) Activities

In 1992, based on available surveillance and case study data, Construction Program researchers working with others in NIOSH undertook a silicosis prevention initiative to reduce new occurrences of silicosis through reduction of workplace exposures. Also starting in 1992, NIOSH began development of a policy document summarizing the health effects of occupational exposure to RCS, including cancer. In addition, starting in 1992 Construction Program researchers began a series of targeted hazard surveys in the construction industry to gain insight into the nature of the RCS exposures. Researchers found that lack of awareness of the hazard and sparse use of dust control devices were major reasons for exposure. The use of more and more powerful and productive construction-related tools during tasks in which crystalline silica was being disturbed without the use of equally effective dust control measures and personal protection was found.

Collaboration and Hazard Awareness

This led to work to determine the effectiveness of available engineered hazard controls for these tasks. An interagency working group on silicosis prevention that included NIOSH, Bureau of Mines (later transferred into NIOSH), MSHA, OSHA, and the U.S. Geologic Survey was established in the mid-1990s. NIOSH partnered with OSHA to raise awareness across industry sectors having the highest risk of worker exposure. Construction was a primary focus of this effort and Construction Program researchers worked with OSHA to help them train their workplace inspectors in the identification of this hazard in the construction industry and in potential means of reducing the hazard. As a result, in 1996 OSHA initiated a national silicosis prevention campaign [Dear J 1996]. A Joint Campaign on Silicosis Prevention was formalized in 1996 as a partnership of the American Lung Association, MSHA, OSHA, and NIOSH [U.S. Department of Labor 1996]. This national public education campaign, “If It’s Silica, It’s Not Just Dust” (www.cdc.gov/niosh/silica/sicampn.html, www.cdc.gov/niosh/topics/silica/newsrel.html), to prevent silicosis resulted in a national conference to eliminate silicosis in 1997. The conference engaged many additional partners from industry, labor, and academia, and involved more than 600 participants from 40 states and five foreign countries [National Conference to Eliminate Silicosis 1997].



Risk factor characterization
A coordinated program to fund projects to drive toxicology/pathology research on crystalline silica originated in the mid-1980s and led to an enhanced understanding that freshly-fractured crystalline silica is more toxic than aged-fractured. This information is important to the construction industry in that many of the high risk exposures involve the fracture of crystalline silica particles (rock and concrete drilling, sandblasting) [Castranova V, Pailes WH, Dala NS, et al. 1996]. In 1992, NIOSH commenced the development of a policy document to support NIOSH testimony on crystalline silica toxicity by reviewing and summarizing the health effects of occupational exposure to respirable crystalline silica, including cancer.

Also, the Construction Program completed and published two peer-reviewed quantitative risk assessments for lung cancer mortality and nonmalignant respiratory disease (NMRD) mortality and morbidity [Rice et al. 2001; Park et al. 2002] based on re-analysis of data from the diatomaceous earth worker study conducted and published by partners at the University of Washington [Checkoway et al. 1997].

Analytical method development
Reliable precise methods for the collection and analysis of silica-containing dusts are a prerequisite for exposure assessment. Construction Program researchers

organized a tri-agency workgroup with OSHA and MSHA, the two federal agencies with authority to regulate and enforce workplace silica exposures. All U.S. crystalline silica workplace sampling and analytical methods were evaluated via collaborative laboratory studies. Questionnaires were used to correlate laboratory practices with results of the American Industrial Hygiene Association (AIHA) Proficiency Analytical Testing (PAT) program. The results were then analyzed statistically to determine the critical factors influencing precision of analytical measurements. This led to standardized methods to insure comparability to national and international occupational limits for silica.

Exposure assessment / hazard identification

During the years 1992-1998, Construction Program researchers conducted 16 construction site visits in West Virginia, Pennsylvania, Ohio, and the District of Columbia) to characterize RCS exposures associated with high risk activities (Appendix 2.3). The Construction Center created and pioneered the use of a Task-Based Exposure Assessment Model (T-BEAM) as a more relevant approach for understanding exposures in construction. In addition to collecting task specific exposure determinant information, the T-BEAM approach actively involved construction workers in the exposure assessment process to obtain their insights on exposure influences and to evaluate control options to reduce and/or eliminate the hazard. T-BEAM survey materials were modified for evaluating silica exposure during masonry tasks, abrasive blasting, and used for characterizing silica exposure among sampled trades on 16 jobs/sites in Massachusetts, Ohio, and New Jersey between the years 1999-2004. More than a dozen different tasks were monitored. Once overexposures to RCS during specific construction industry tasks were identified, emphasis then shifted to evaluating engineering controls (dust controls).

Intervention and engineering control development and evaluation

Intervention and control development and evaluation have addressed the following:

Sandblasting

Construction research projects addressed the following questions: 1) Are substitute materials for silica sand commercially available in sufficient quantities to serve industry? 2) Are these substitutes' effective and cost efficient abrasives? 3) What is the pulmonary toxicity of these substitutes compared to silica sand?

Jackhammer and highway construction tasks

Construction Program researchers collaborated with New Jersey state health and transportation departments, OSHA, and construction contractors and unions to assess engineering controls during silica dust exposures associated with highway construction and bridge maintenance [Valiante 2004, Echt 2003].

Sawing, grinding

Local exhaust ventilation (LEV) and wet-saw systems that are commercially available were evaluated for controlling silica dust during concrete sawing and grinding and mortar tuck pointing.

Mobile equipment cabs
With much construction work involving the use of mobile equipment such as haul trucks, rock drills, bull dozers, and earth movers of all types, the construction program collaborated with the Mine Safety and Health Administration (MSHA), mine operators, and equipment manufacturers to find the most cost-effective ways to improve dust protection in heavy equipment cabs.

Drilling tasks
The construction program conducted several projects to develop technologies to reduce dust at surface mine and construction rock drilling sites. These include studies to 1) measure the dust collection efficiency of the commonly used "Rotoclone" dust collector, 2) establish the optimum water flow rates for wet drilling, 3) establish the dust reductions obtained with better maintenance of dry collectors, 4) improve the dust capture efficiency of the dust collection system, 5) reduce the secondary dust emissions from the dust collection system, and 6) identify the impact of dust collection system malfunctions and allow operators to evaluate the performance of drill dust collection systems.

The Construction Center is working with the International Union of Painters and Allied Trades (IUBAT) to establish a "Silica-smart contractor certification program" which stresses training, respiratory fit-testing, and medical examinations. In addition, engineering controls for masonry work which were shown to be effective in a controlled setting will be tested on construction sites (Appendix 2.3).

C) Outputs and Transfer

Appendix 2.3 provides a complete listing of outputs. Program researchers have authored a total of 41 peer reviewed journal articles and provided 145 presentations, and developed an analytical method and 12 NIOSH and Center publications related to silica issues.

Risk factor characterization

The silica hazard review policy document was completed in 2002 and is internationally disseminated electronically on the Internet via the NIOSH website and in hard copy [NIOSH 2002]. Nearly 7,000 hard copies of the hazard review have been distributed worldwide and a reprinting is in progress. This publication may be found on the NIOSH silica topic page http://www.cdc.gov/niosh/topics/silica/default.html. The NIOSH silica topic page had 8223 visits from December, 2006 through May, 2007. NIOSH considers the hazard review and the silica topic page as key resources (http://www.cdc.gov/niosh/keyresources.html). In addition, information from this work has been disseminated through national and international presentations.

Analytical method development

Information from analytical method development was transferred to OSHA and MSHA, and through working with international voluntary consensus standard setting groups. This work resulted in a new analytical method description [Key-Schwartz 2004].

Exposure assessment / hazard identification

Detailed hazard surveillance and Health Hazard Evaluation (HHE) reports were distributed to contractors, employees, OSHA offices, and the NIOSH internal field work coordinator. The reports contained information on the concentrations of RCS measured as well as recommendations toward reducing and/or eliminating the hazard. Several peer reviewed journal articles were published (Appendix 2.3). Several articles were published in trade journals (*Professional Roofing, Roofing Contractor, Coatings Pro*, and *National Union Newsletter,* for example).

The construction program published an Alert (English and Spanish) requesting assistance in preventing silicosis in the construction industry [NIOSH 1996]. It may be found on the NIOSH silica topic page http://www.cdc.gov/niosh/topics/silica/default.html. Over 73,000 hard copies have been distributed.

To reach construction workers on a personal level, the Construction Program produced a bulletin which included a real-life story of one unfortunate worker who was diagnosed with occupational silicosis. [NIOSH 1997A]. Over 127,000 copies of this publication have been distributed. It was mailed to over 5000 masonry contractors.

The Program produced a publication targeted to rock drilling workers and their employers, [NIOSH 1997B]. Almost 50,000 copies of this publication have been printed and distributed.

Construction Program personnel met with OSHA to discuss the projects findings and then trained OSHA Special Emphasis Program trainers on what had been found and where OSHA should look within the construction industry for overexposure problems. Then they provided OSHA with an awareness and training package with 135 slides and a narration. OSHA uses many resources that were developed by the Program (see http://www.osha.gov/SLTC/silicacrystalline/index.html).

The construction center published a fact sheet: *On The Beam*, http://www.uml.edu/Dept/WE/COHP/index.htm, and guidance material, Guides for Managing Silica Control Programs in Construction, http://www.blueprintproject.org. The center also created articles and a Hazard Alert card that were used and disseminated by unions and through the www.elcosh.org web site. The Center worked with the International Union of Painters and Allied Trades in developing and delivering silica training to apprenticeship instructors, contractors, and journeymen painters as part of the course: Science, Air Monitoring, Written Programs and Testing Devices: Particulates, at Marshall University in West Virginia in 2001.

Intervention and engineering control development and evaluation

Since 1994, Construction Program staff have co-chaired the Engineering and Work Practices Controls Work Group made up of labor, government, industry, and academia. This group provides a forum in which to transfer what has been learned concerning specific silica dust exposure controls. Construction Center researchers have made numerous presentations with audiences of labor, industry and government.

With the Building and Construction Trades Department, AFL-CIO, the Construction Center drafted a silica standard which was forwarded to OSHA in support of new regulations. Construction Program engineering control survey reports were produced for each worksite assessed, and several peer-reviewed papers were published. The major transfer activity was to OSHA for their use in understanding these exposures and development of a silicosis control standard for the industry.

Research into the availability and toxicity of substitute abrasives for silica sand in abrasive blasting produced both peer and non peer-reviewed publications (Appendix 2.3). This work provided industry with data on the blasting effectiveness and costs of abrasive substitutes and on airborne metals generated during the use of blasting substitutes. In an acute pulmonary exposure study, it was found that specular hematite and steel grit were less toxic than silica sand, while coal slag and olivine were more toxic. Numerous presentations and direct communications with industrial partners were made (Appendix 2.3).

Research into the use of environmental cab enclosures to protect workers during dusty tasks was published in peer-reviewed journal articles [Moyer 2005, Cecala 2004] and in trade journals and conference proceedings.

Trade journals and conferences were selected to reach the appropriate target audience. A video that gives guidelines for improving the dust protection efficiency of cabs was produced (http://www.cdc.gov/niosh/mining/products/product81.htm). The International Union of Operating Engineers (a major construction industry union) requested copies of the video. Trade organizations such as the Industrial Minerals Association – North America and the National Stone, Sand & Gravel Association have asked for this video.

More than 2,000 copies of each of the enclosed-cab technology news bulletins were distributed [NIOSH 2001A, NIOSH 2001B].

D) Intermediate Outcomes

Risk factor characterization

The construction program silica risk assessments have been used for regulatory and standard-setting efforts nationally and internationally. The California Office of Environmental Health Hazard Assessment used this work to support a chronic Reference Exposure Level that was adopted in 2005 http://www.oehha.ca.gov/air/chronic_rels/silica_final.html.

The construction program risk assessments have been cited by the UK's Health and Safety Executive review and by the ACGIH documentation in which they lowered their TLV.

The hazard review [NIOSH 2002] has been cited in at least 36 peer-reviewed publications and documents worldwide (Appendix 2.3.1).

Analytical method development

In 2005, the Construction Program's analytical method development work was used by AIHA to lower its PAT analytical limits by switching to liquid deposited PAT samples. Laboratories have since shown proficiencies at levels that will allow OSHA to establish a PEL of 0.05 mg/m3 RCS. The construction program's work to refine the analytical method resulted in the issuance of National Institute for Standards and Technology (NIST) certified standard series 2950 in January 2007. These quartz deposited filters, ready for analyses, provide standards down to 5 ug per sample versus the previous 15-20 ug per sample. Use of these low standards will help laboratories measure lower levels of RCS reliably and supports the lowering of national and international exposure limits. As a result, the draft OSHA rule-making for crystalline silica includes a new definition of “compliant laboratory” and includes a mandate to use NIST-certified reference materials.

Exposure assessment / hazard identification
The Construction Program’s exposure assessment and interaction with OSHA resulted in OSHA’s Special Emphasis Program on silicosis prevention targeting silica exposures in the construction industry. In addition, recently OSHA reassessed its inspection procedures for concrete roofing tile contractors in Arizona.

As a result of the program and center raising the awareness that workers and their employers aren’t fully trained on this topic, the Construction Safety Council developed new training programs for OSH trainers and construction workers (http://www.buildsafe.org).

During the first 20 months (10/96 – 6/98) of producing these materials, the Construction Safety Council trained 771 construction employees and 847 employers for a total of 1618 people. Others have used it too.

Intervention and engineering control development and evaluation
The New Jersey Department of Health developed a publication (Spanish and English): To my doctor: What physicians need to know about silicosis in

construction, demolition and renovations workers (http://www.state.nj.us/health/eoh/survweb/sili2web.pdf).

The International Union of Bricklayers and Allied Crafts (IUBAC) union put in place collective bargaining agreement language in Michigan, New Jersey, and Massachusetts which requires use of water and/or local exhaust ventilation when cutting and/or grinding masonry.

OSHA sponsored seminars for their compliance officers throughout region three where *Center Guides for Managing Silica Control Programs in Construction* (blueprint guides) were presented. OSHA has distributed the guide though its outreach and compliance programs.

The trade journal Masonry Construction published, *Protecting Tuckpointing Workers: Here Are Some Guidelines for Mitigating Dangerous Dust Exposures*, in 2005. A construction industry journal – Engineering News Record published a cover story titled: *The Scourge of Silicosis – Deadly Dust can Leave you Gasping at the Consequences* in 2000. Both were based on Program information.

California OSHA has used the Program's data in the development of regulations for controlling crystalline silica exposure in the state of California. In addition Cal/OSHA is beginning the regulatory process to enact controls for dry-cutting and working of masonry and is using the construction program's data and material.

The following groups have distributed information developed by the Program concerning the use of local exhaust ventilation during masonry grinding and sawing: Associated General Contractors, Associated Builders and Contractors, International Masonry Institute, International Union of Bricklayers and Allied Craft Workers Union, Western Washington Cement Masons, safety directors for large general contractors in Washington State.

The efforts of the New Jersey silica partnership resulted in New Jersey requiring the use of engineering and work practice controls to limit silica exposures. New Jersey also enacted a law on December 9, 2004 prohibiting the dry grinding and dry sawing of masonry materials. [New Jersey Department of Transportation 2004].

The NJ Laborers' Health and Safety Fund, improved the jackhammer water-spray dust control, making it easier to build, cheaper to make, and more reliable in the field [Hoffner 2006]. They distributed a how-to guide and held seminars in New Jersey on the device. One public works agency has mounted water tanks on their maintenance vehicles to supply water to jackhammers and gasoline-powered concrete/masonry saws.

As a result of working with the Construction Program, Clean Air Filter® (www.Cleanairfilter.com) recognized a need for its retrofit filtration-pressurization system for equipment cabs. In response, they added factory production capability to meet the growing demand. While company policy prohibits them from releasing sales information, they have clearly stated that they do have a significant market. Clean Air Filter® also contributed notable resources into a Cooperative Research and Development Agreement (CRADA) with the Construction Program to develop a quality control field test method for evaluating the environmental integrity of enclosed cabs. A Patent-Pending leakage test was developed as a result of this joint research [Organiscak et al. 2003]. Clean Air Filter® is negotiating future commercialization of this patented leak test with CDC.

Another cab filtration manufacturing company, Sy-Klone International, LTD, is working with several heating, ventilation, air-conditioning companies and the Construction Program to incorporate their intake filtration-pressurization system onto heating and air conditioning units on mobile equipment cabs.

The engineering control evaluation work was used by OSHA in the preparation of the technology feasibility study and cost and impact analysis that is part of the docket for the draft silica standard for the construction industry.

E) External Factors

Prevention of silicosis depends largely on construction industry management. The construction bidding process needs to consider the value of controlling these exposures and should include contract language to require certain measures to insure all contractors competing for work are prepared to provide a safe working environment. Construction is extremely competitive. Therefore any measure that may increase costs for an individual contractor or group of contractors may put them at risk of losing work to more competitive contractors who exclude such provisions. Many contractors and some workers see the increased labor time and capital costs that might be associated with use of engineering controls as cost prohibitive.

The infrastructure for addressing occupational health problems on construction sites is not well developed. Full time on-site safety personnel, joint labor/management safety and health committees, and equipment for reducing the generation of occupational health hazards is generally lacking on most construction sites in the U.S.

ACGIH lowered the TLV for crystalline silica to 0.025 mg/m3 in April 2006. OSHA is considering changing their PEL from a formula (0.1 mg/m3 at 100% quartz) to 0.050 mg/m3 and broadening their requirements when crystalline silica dust exposure is a workplace hazard. OSHA has been working on a new crystalline silica standard that may address many of the exposure problems currently found in the industry and the construction program will continue to provide updated and new data and information on this hazard.

Since silicosis is a disease with a relatively long latency period and is often misdiagnosed or diagnosed much later in life, employers are not likely to bear the economic burden that would otherwise be associated with increased workers compensation costs. This is particularly true in construction where employees are relatively transient and may work for many contractors over the course of their careers. This fact makes research and surveillance all the more important in linking workplace exposure to the on-set of disease.

F) What's Ahead?

NIOSH developed a draft program strategic goal addressing silica issues and the NORA Construction Sector Council selected silica as one of three key health hazards to focus on over the upcoming decade. This will lead to a variety of research and research to practice activities.

Ongoing research on silica includes the following:

NIOSH obtained data on non-malignant respiratory disease morbidity from three investigators/collaborators and initiated a pooled analysis and quantitative risk assessment. The pooled analysis uses demographic, employment, and exposure data from studies of Chinese tin miners, South African underground gold miners, and U.S. diatomaceous earth mining and processing workers. Data were analyzed and two draft manuscripts are in revision. NIOSH partners include: OSHA, Tongji Medical College, University of Cincinnati, University of Washington, and Emory University. Data and information from efforts such as this will continue to be perused for application to the construction sector.

Analytical techniques will continue to improve as additional NIST-certified SRMs come on the market in 2007 (quartz and cristobalite on filter). Beta testing was completed in 2006. ISO Guidelines for method selection for sampling and analysis of crystalline silica are expected. The Construction Program will support stricter exposure standards for crystalline silica globally. In the near term, we will provide technical assistance via World Health Organization (WHO) and Pan-American Health Organization (PAHO) for the purpose of establishing accredited laboratories in Latin America.

Continued surveillance activities will result in future NIOSH work-related lung disease surveillance reports which may provide more detailed information on silicosis in the construction industry. This data will be used by the construction program to further target unacceptable exposure and disease pockets.

Current international education and information efforts are just underway relating to silica-related disease prevention. The Program is teaming with the World Health Organization and the Pan American Health Organization for that effort.

The Building Trades Safety and Health Committee requested the development of a module on crystalline silica for the Building Trades Unions' Smart Mark training curriculum. We are working with a curriculum development contractor and the committee to complete the module by July 2007. The Construction Center expects 3000-4000 instructors to receive the training program over the next two to three years, and based on distribution of student booklets in the past, these instructors will train up to 40,000 workers per year.

The construction program researchers are currently conducting research that seeks to transfer engineering control knowledge from mining machinery to asphalt milling machines. In addition, work is in progress to issue Workplace Solutions, short, non-technical documents that provide practical guidance on dust control technology. Research into reducing silica dust levels around surface drilling operations will continue under the mining research program. The results of this research will continue to have application in the construction industry.

Construction program toxicology data on abrasive blasting substitutes will be included in the OSHA Standard on silica due for public distribution in 2007. The construction program has completed acute studies in rats and has collaborated with the National Toxicology Program (NTP) to design longer-term studies with silica substitutes that will provide dose-response data applicable to making recommendations for occupational exposure limits. Five alternative blasting agents will be tested to establish their potential to induce lung fibrosis as result of whole body inhalation exposure. Testing data is needed because of the high production volumes of these agents, the large number of workers exposed, and the inadequacy of present toxicity data to determine safe exposure levels. Data from testing will provide a foundation for recommendations regarding the use of alternatives to silica sand, and should provide dose-response toxicity data for risk assessment and development of occupational exposure limits.

The construction program will produce a web topic page devoted to providing up to date prevention information on the many hazards associated with abrasive blasting. The hazards include dust exposure, carbon monoxide poisoning, lead poisoning, noise, confined spaces and falls from scaffolding.

A new program intervention project starting in 2007 will gather and disseminate information regarding respiratory protection programs and respirator interface with other personal protective equipment (PPE) at thirty worksites active within the road and transportation building sector of the U.S. construction industry. The project will provide appropriate intervention materials to aid in improving the respirator programs at the studied worksites. Program staff will evaluate the effectiveness of the recommended interventions and those that prove useful will be shared with the construction industry.

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Appendix for Subgoal 2.3

Risk factor characterization

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Appendix 2.3. Additional intermediate outcomes

Publications that have cited the NIOSH RCS Hazard Review publication are listed below.

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Morriss AP, Dudley SE [2006]. Defining what to regulate: silica and the problem of regulatory categorization. Administrative Law Review Summer:70 pp.

Mulenga EM, Miller HB, Sinkala T, Hysong TA, Burgess JL [2005]. Silicosis and tuberculosis in Zambian miners. Int J Occup Environ Health 11(3):259-262.

Mulloy KB [2003]. Silica exposure and systemic vasculitis. Environ Health Perspect 111(16):1933-1938.

Murashov V, Harper M, Demchuk E [2006]. Impact of silanol surface density on the toxicity of silica aerosols measured by erythrocyte haemolysis. J Occup Environ Hyg 3(12):718-23.

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National Toxicology Program (NTP) [2005]. Silica, Crystalline (Respirable Size). 11th Report on Carcinogens:2 pp.

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Peretz A, Checkoway H, Kaufman JD, Trajber I, Lerman Y [2006]. Silica, silicosis, and lung cancer. Isr Med Assoc J 8(2):114-118.

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Sub goal 3.2.4 Asphalt Fume Exposures and Various Health Effects

A) Issue

Asphalt is used in two major construction operations: roofing and road building. The heating of asphalt during application results in a complex mixture of asphalt fumes. An estimated 300,000 asphalt paving workers and 46,000 roofing workers are routinely exposed to the fifty-plus organic compounds known to be present in asphalt fumes.

NIOSH's efforts on asphalt pre-date the construction program. NIOSH prepared a criteria document on asphalt in 1977. In 1988 testimony to OSHA regarding an update of Permissible Exposure Limits (PELs), NIOSH recommended that asphalt fumes be considered a potential occupational carcinogen [NIOSH 1988].

Several factors stimulated early Construction Program activity on asphalt. OSHA's efforts to revise the asphalt fumes PEL generated interest among stakeholders and researchers regarding hazards and exposure assessment. The 1991 Intermodal Surface Transportation Efficiency Act was an additional factor as it required each state to use a minimum quantity of "crumb rubber modified" (CRM) hot mix asphalt paving material. Because of industry and labor concerns over the lack of available information on the environmental and human health effects resulting from the use of CRM hot-mix asphalt, Construction Program researchers were enlisted through an Interagency Agreement with the Federal Highway Administration to evaluate occupational exposures among asphalt road workers in June 1994.

The study protocol included developing and field testing new methods to assess asphalt fume exposures, characterizing occupational exposures to CRM and conventional (CONV) asphalt, as well as evaluating potential health effects associated with CRM asphalt and CONV asphalt. This led to development of partnerships with trade associations and unions representing paving and roofing interests and the Asphalt Institute. A partnership approach was used to guide an extensive research effort along with development of materials to communicate findings and prevention strategies to stakeholders.

This partnership approach, as a strategy to facilitate research and intervention to address asphalt fume exposures has become a model for projects in emphasis areas within the Construction Program and other industry sectors. The strategy of involving multiple research and applied science disciplines and enlisting the assistance of multiple partners and stakeholders supports the research to practice (r2p) initiative. The work in this area has involved exposure characterization, identification and development of controls, outreach and intervention, provision of guidance and recommendations for safer work practices, and adoption and implementation by stakeholders, partners, and customers.

B) Activities

Construction Program research with asphalt has involved the coordinated efforts of several disciplines across NIOSH. These include analytical chemists, toxicologists, risk assessors, industrial hygienists, engineers, and worker education experts. Research has focused on filling asphalt fume data gaps. Asphalt fumes present challenges because they contain complex mixtures, the types and amounts of contaminants generated can vary based on temperatures and process variations, and because this variation makes research findings less comparable than studies of individual contaminants. For example, National Asphalt Pavement Association (NAPA) representatives pointed out that earlier studies evaluating cancer health risks had been based on fume condensates collected at much higher temperatures than encountered in normal paving operations. NAPA provided evidence which showed the lower temperatures of actual paving operations were not expected to produce the same types and concentrations of contaminants. To address this and other relevant issues and concerns with asphalt fumes, the Construction Program asphalt research has involved a significant effort to promote discussions and collaboration with construction partners.

For paving, research partners include the Federal Highway Administration, International Union of Operating Engineers, Laborers International Union of North America, NAPA, and the Asphalt Institute. For roofing, partners include the Asphalt Roofing Manufacturers' Association, the National Roofing Contractors' Association, the Asphalt Institute, and the United Union of Roofers, Waterproofers, and Allied Trades.

Construction Program research has involved these categories:

Methods research
Construction Program researchers developed methods to generate asphalt fumes that simulate occupational exposures as a prerequisite for animal studies to increase understanding of asphalt hazards. Additional analytical chemistry methods work was performed to improve exposure sampling and analysis methods. This involved efforts to develop methods for measuring the biologically active chemical fractions of interest and to insure traditional measures of reliability and accuracy were improved.

Health effects research
Construction Program researchers presented asphalt as a priority nomination to the National Toxicology Program (NTP). On the basis of that nomination, NTP accepted and agreed to fund research. Construction Program researchers were consulted extensively on chemistry related issues during the development of a protocol entitled "Subchronic Twenty-eight Day Toxicity Study of Asphalt Fumes in Male Fischer 344 Rats." The objectives of the study were to provide data on non-carcinogenic endpoints, develop an exposure system and identify

concentrations which could be used in a future two-year chronic carcinogenicity study, to determine the potential target organ toxicity of asphalt fumes and the concentrations that cause acute toxicity.

To promote sharing of technical expertise and assess the state-of-the-science of health effects research with asphalt fume, Construction Program researchers organized and chaired two meetings (February 1996 and June 1997) with stakeholders and partners representing the Asphalt Institute, NAPA, National Roofing Contractors' Association, Asphalt Roofing Manufacturers' Association, and Roof Coating Manufacturers' Association. Both events promoted the exchange of research information and fostered communications. A synopsis of first forum was sent to each attendee. The second forum attracted an international audience. Both were announced in the *Federal Register*.

Exposure characterization

An Interagency Agreement was formed with the Federal Highway Administration to evaluate occupational exposures among asphalt road workers in June 1994. The study protocol included developing and field testing new methods to assess asphalt fume exposures, characterizing occupational exposures to CRM and conventional (CONV) asphalt, and evaluating potential health effects associated with CRM asphalt and CONV asphalt. Through this effort, seven site evaluations were completed between 1994 and 1997.

Prevention research

NAPA, through an agreement with the Department of Transportation (DOT), requested that Construction Program researchers assist the five asphalt paver manufacturers representing more than 80 % of the highway-class paver market. Accordingly, this project provided data on occupational exposure and health effects associated with asphalt fume exposure to NAPA. In addition, the Construction Program assisted the manufacturers with prototype designs to control asphalt fume emissions from paver vehicles and independently evaluated the performance of each prototype. As a follow up, the Construction Program researchers met in September 2000 with representatives of industry, labor, government, and academia to discuss research needed to completely assess the health risks associated with exposure to asphalt.

The major activities and highlights of this project in order to ensure development of engineering controls for pavers included the following:

- Field studies to identify the most prolific areas of asphalt fume production
- Instruction of asphalt paver design engineers collectively on engineering control design fundamentals
- Work with each manufacturer individually to develop unique and proprietary prototype control designs
- Development of novel lab-based testing protocol to evaluate the performance of the controls and identify recommendations for improved performance
- Performance evaluations of the controls during field paving operations
- Meetings between industry, government and labor partners which resulted in the development of a consensus guideline and voluntary agreement to incorporate engineering controls on all pavers manufactured after July 1, 1997.
- 13 professional presentations at conferences and workshops
- Provision of 12 in-depth survey reports
- Published numerous articles in trade literature (a recent Google search of the Construction Program asphalt paving partnership resulted in over 750 hits, covering state, local, federal, industry, trade-media, labor-related Websites)
- Provided the testing protocol that was adopted as the engineering controls test and evaluation method within the voluntary agreement between industry, organized labor, and OSHA.

Development of roofing work practice guidance

Construction Program researchers developed an educational document entitled *Reducing Roofers' Exposure to Asphalt Fumes* in partnership with the National Roofing Contractors Association and the United Union of Roofers, Waterproofers, and Allied Workers. This document has served as a training guide for employers and workers with recommendations for limiting asphalt fume exposures during application of hot asphalt to roofs. The document has been incorporated into the safety and health training program conducted by the National Roofing Contractors Association.

C) Outputs and Transfer
(More complete listing is provided in Appendix 3.2.4)

Construction Program researchers have authored at least 14 peer-reviewed journal articles, more than 18 additional publications (NIOSH documents, scientific and technical reports, trade journal articles, and others), and provided more than 30 presentations on asphalt topics.

The Construction Program used regularly scheduled partnership meetings as a mechanism to share research results with stakeholders. These were held in 1996 through 2001. One meeting of specific significance was convened by the Construction Program in partnership with other NIOSH programs as a 2-day workshop entitled Meeting for Identifying Priority Asphalt Research in September of 2000. It included four workgroups: 1) Sampling and Analytical; 2) Human Studies and Epidemiology; 3) Toxicology and Laboratory Research; and 4) Control Technology. In addition, an asphalt Web Topic page was developed and used to facilitate transfer of Construction Program asphalt publications. Additional outputs organized by research category are provided below:

Methods research
The asphalt fume generation system is the result of the methods research. It was described in multiple journal articles such as: *Characterization of asphalt fume composition under simulated road paving conditions by GC/MS and microflow LC/Quadruple time-of-flight MS [Wang et al. 2001]*. The design and experimental results were shared with asphalt partners at informational exchange meetings, two symposia planned and coordinated by Construction Program researchers (1996 and 1997), and subsequent regularly scheduled technical review meetings organized and chaired by the Construction Program researchers.

Because of the limited nature of existing sampling and analytical methods for asphalt fumes, two new methods were developed and tested. We used these methods to evaluate the sulfur polycyclic aromatic compounds (PAC), the total PAC content, and the mutagenic potential of CRM and nonmodified asphalt. The analytical methods were published as NIOSH method 5506 (revised) and 5402 and broadly disseminated in journal articles: e.g., *Development of a Flow-Injection Fluorescence Method for the Estimation of Total Polycyclic Aromatic Compounds in Asphalt Fumes* [Neumeister CE, Olsen LD, Dollberg DD 2003]. The methods were shared with asphalt partners at informational exchange meetings and at professional conferences, with more than 15 scientific presentations given at scientific meetings. Included were: the Pittsburgh Conference & Exposition on Analytical Chemistry and Applied Spectroscopy, American Industrial Hygiene Conference & Exposition, National American Chemical Society meetings, Environmental Mutagen Society, Society of Toxicology, X2004 Exposure Assessment in a Changing Environment, and Health Effects of Occupational Exposure to Emission from Asphalt/Bitumen Symposium.

Health effects research

In 2001, Construction Program researchers produced a document evaluating the health effects and other relevant data that have become available since publication of the 1977 NIOSH document Criteria for a Recommended Standard: Occupational Exposure to Asphalt Fumes. The document, entitled Hazard Review: Health Effects of Occupational Exposure to Asphalt [NIOSH 2001a], includes an assessment of chemistry, health and exposure data from studies in animals and humans exposed to raw asphalt, paving and roofing asphalt fume condensates, and asphalt-based paints. The document serves as a basis for identifying future research to reduce occupational exposures to asphalt.

In addition, Construction Program researchers also published results of the first comprehensive study to identify and characterize irritant effects of acute asphalt fume exposures for road paving workers evaluated at seven sites in six states [Tepper et al. 2006].

Exposure Characterization

Following the completion of the Hazard Review document [NIOSH 2001a] described above, an international risk assessment document was developed for asphalt based on the Construction Program research efforts and publications. It is a summary of all of the data considered relevant to the topic. The document was prepared by the Construction Program researchers and submitted for publication by the *World Health Organization International Programme on Chemical Safety* [WHO 2004: IPCS concise international chemical assessment document 59: Asphalt (Bitumen). Geneva, Switzerland: WHO/IPCS].

Prevention research

Resulting paver engineering control designs and test protocols were described and disseminated in multiple presentations and publications (e.g., [Mead et al. 1999]. Specific guidance was provided in technical research documents such as the *Engineering control guidelines for hot mix asphalt pavers* [NIOSH 1997], which has had over 32,300 printed copies distributed from 1997 to 2007.

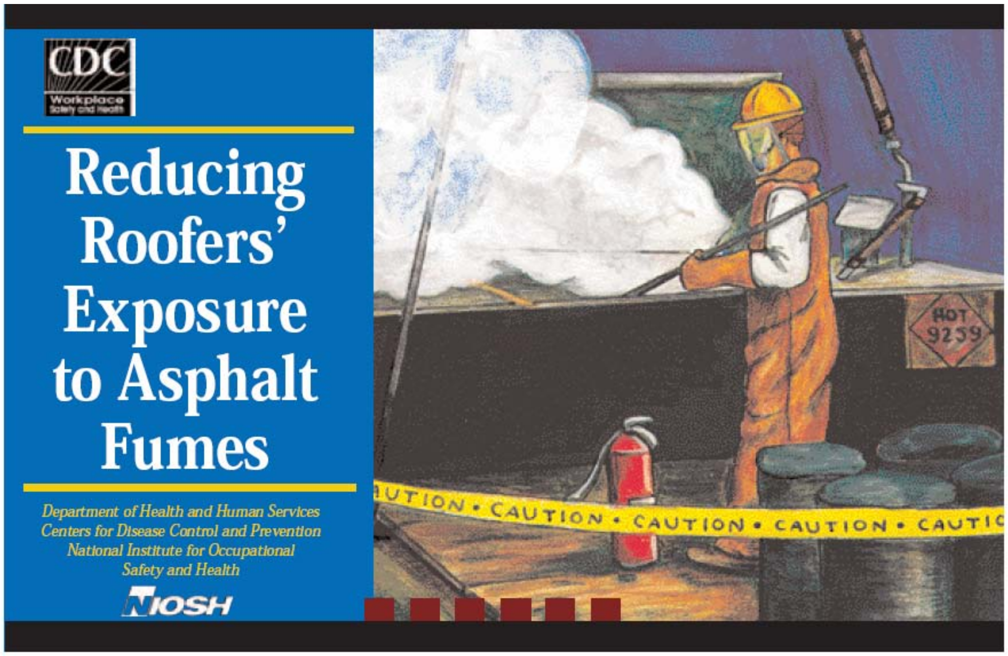
A two-day public forum convened by Construction Program researchers in Cincinnati in July 1996 provided the impetus for research, guidance, and informational materials relating to asphalt fume exposures during roofing operations. Following this meeting, the need for educational tools was recognized and addressed through the development of a booklet, a video, and a training guide. These and other materials were developed by Construction Program researchers in collaboration with the National Roofing Contractors' Association and the United Union of Roofers, Waterproofers, and Allied Trades.

Examples of the technical and educational documents and publications describing the resulting roofing work practices and controls include the following:

- Asphalt Fume Exposures During the Manufacture of Asphalt Roofing Products [NIOSH 2001b]
- Reducing Roofers' Exposure to Asphalt Fumes [NIOSH 2003a]
- Asphalt Fume Exposures During the Application of Hot Asphalt to Roofs [NIOSH 2003b].

A total of 15,289 copies of these have been disseminated or requested by industry stakeholders.

Guidance from these documents was adopted and incorporated into safety and health programs of collaborators and stakeholders.



Transfer activities
Dissemination of the publications and resulting guidance was performed through the stakeholders and partners involved in their development, specifically the Asphalt Roofing Manufacturers' Association, the National Roofing Contractors' Association, the Asphalt Institute, and the United Union of Roofers, Waterproofers, and Allied Trades.

D) Intermediate Outcomes

Methods research
The asphalt fume generation system and characterization method has become the standard protocol used in testing by the NTP, and new analytical methods NIOSH 5506 (revised) and 5402 developed by Construction Program

researchers are currently used by asphalt industry stakeholders for evaluating exposures.

Health effects and exposure characterization research

Construction Program asphalt health effects research outputs are used by the WHO/IPCS, IARC, other Federal agencies (Federal Highway Administration, Environmental Protection Agency) and industry stakeholders.

Prevention research

Road Paving

Based on preliminary data collected by Construction Program researchers, the Congressional mandate for the use of crumb-rubber asphalt was eliminated. As of July 1997, all new highway-class pavers are manufactured with ventilation controls to reduce exposure to asphalt fumes. With a service life of 10 years, more than 90% of all current highway-class pavers now have these controls installed with 100% being obtained within the next year (2008). Construction Program researchers recently conducted a survey with exposure monitoring to evaluate the effectiveness of controls for highway class pavers [Mickelson et al. 2006]. Monitoring was performed to evaluate current highway class pavers equipped with controls to reduce asphalt fumes, occupational exposure levels, and ventilation flow rates, and a user acceptance survey was conducted. Results of the survey indicate that the majority of engineering controls were successful in terms of their use, general reliability, and overall effectiveness in keeping exposures below the recommended exposure limits.

In recognition of the importance of the partnerships, the project was a 1998 finalist in the Innovations in American Government award competition. The project also received the following awards: 2000 Alice Hamilton Award (Engineering Category), Michigan Industrial Hygiene Association Best Peer-Reviewed Journal Article Award, First NORA Partnering Award, National Association of Government Communicators Blue Pencil Award (for asphalt paver guidelines document), US PHS Engineering Literary Award, and was a CDC Charles C. Shepard Science Award nominee.

End outcomes

Construction Program research with commercial asphalt pavers and the development of engineering controls have produced documented reductions in asphalt fume exposure of 50-80% [NIOSH 1999; Mickelson et al 1999; Mickelson et al. 2006]. Because the controls have been broadly implemented and are well accepted within the highway class paving industry, the results of this effort translate into potential for significantly reducing asphalt fume exposures among 300,000 highway class road paving workers. Evaluations of control on new pavers at 12 sites across the United States indicate that workers' personal exposures to total particulate matter and benzene soluble matter (two primary contaminants of concern) were both consistently reduced to levels below U.S. government recommended values [Mickelson et al. 2006].

Roofing
Resulting roofing work practices and controls were adopted by industry groups and integrated into their safety and health programs (e.g., National Roofing Contractors Association).

E) External factors

In 1991, Congress enacted the Intermodal Surface Transportation Efficiency Act , which required each state to use a minimum quantity of CRM hot-mix asphalt paving material. In 1994, the Federal Highway Administration formalized an Interagency Agreement with the Construction Program to evaluate occupational exposures among asphalt road workers.

F) What's Ahead?

Based on the partnerships formed and the success of the partnership model developed during this project, a new research project is being initiated by the Construction Program researchers to reduce worker exposure to asphalt and silica during asphalt milling. Many of the partners involved in the asphalt pavers' project are also involved in the asphalt milling project. As part of the ongoing effort to improve upon the technology for monitoring asphalt fume exposures, one or more methods for reliably determining PAHs in asphalt will be developed and published.

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NIOSH [2003a]: Reducing Roofers' Exposure to Asphalt Fumes. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2003-107.

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Neumeister CE, Olsen LD, Dollberg DD [2003]: Development of a Flow-Injection Fluorescence Method for the Estimation of Total Polycyclic Aromatic Compounds in Asphalt Fumes. AIHAJ 65(5):618-624.

Tepper AL, Burr GA, Feng HA, Singal M, Miller AK, Hanley KW, Olsen LD [2006]: Acute symptoms associated with asphalt fume exposure among road pavers. Am J Ind Med 49(9):728-739.

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Appendix 2.4 Outputs

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-Journal articles

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Health effects and exposure characterization research
-Journal articles

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Wang J, Lewis DM, Castranova V, Frazer DG, Goldsmith T, Tomblyn S, Simpson J, Stone S, Afshari, A, Siegel PD [2001]: Characterization of asphalt fume composition under simulated road paving conditions by GC/MS and microflow LC/Quadruple time-of-flight MS. Analytical Chemistry 73:3691-3700.

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Miller A, Burr G [1997]: NIOSH/FHWA Asphalt Project. Invited Speaker at the Michigan Construction Safety Conference; Lansing, MI.

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-Additional outputs (such as Fatality Investigation Reports, Other Publications, Contractor reports, Patents, Workshops/Conferences/Meetings)

WHO [2004]: IPCS concise international chemical assessment document 59: Asphalt (Bitumen). Geneva, Switzerland: World Health Organization. International Programme on Chemical Safety. Prepared by Wess J, Olsen LD, Sweeney MH.

Prevention research
Journal articles

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Subgoal 2.5 Dermal Exposures and Various Skin Disorders in Construction

A) Issue

There are several agents in the construction industry such as Portland cement, epoxies, solvents, and preservatives that can cause skin disorders such as contact dermatitis. Contact dermatitis can be a painful and debilitating disease and is an important cause of occupational disability [Burnett et al. 2003]. There is little published literature in the United States on contact dermatitis in construction workers.

Portland cement is used in concrete, mortar, terrazzo, stucco, and related construction materials and is known to cause both irritant and allergic contact dermatitis [Stern et al. 1993]. It is extremely alkaline, and it contains trace amounts of hexavalent chromium. The alkalinity of wet cement contributes to irritant contact dermatitis and the hexavalent chromium is a strong sensitizing agent that is responsible for allergic contact dermatitis in cement workers worldwide [Halbert et al. 1992; Conde-Salazar et al. 1995; Freeman 1986]. Allergic contact sensitization is considered to last life-long, thus making life-long allergen avoidance necessary, and since there are no known cures for contact allergy, primary prevention is important.

Large numbers of workers have potential dermal exposures to Portland cement. Center researchers estimate that more than 1,300,000 construction workers are employed in occupations with exposures to wet cement [CPWR 1999]. Exposures can occur from working with a variety of construction materials that contain Portland cement. Examples of trades with potential exposure include: bricklayers, cement masons, concrete finishers, construction craft laborers, hod carriers, plasterers, terrazzo workers, and tile setters. Affected construction trade unions report that skin effects are common among cement-exposed workers. Multiple other trades are exposed intermittently.

In addition to the risk of skin disease from contact with Portland cement, workers in construction have significant exposure to sunlight, and a concomitant risk for skin cancer [Espinoza et al 1999].

B) Activities

Surveillance for contact dermatitis
Construction Center researchers analyzed available data from the published literature, occupational exposure surveys, and injury and illness statistics to identify construction workers' exposure to potential dermal hazards.
We did economic analysis of jobsite and industry wide interventions, as well as economic characterization of impact of disease on contractors, workers, workers' compensation systems, private insurance, and society.

Collaboration to develop best practices for work with wet cement

Construction Program and Center researchers established a "Consortium on Preventing Contact Dermatitis" in 1995. Consortium partners included NIOSH, CPWR, the Operative Plasterers & Cement Masons International Association, and FOF Communications. The Consortium Steering Committee included additional members from the National Ready Mixed Concrete Association; the American Portland Cement Alliance, the International Brotherhood of Teamsters, and the International Union of Bricklayers & Allied Craftsworkers. The Construction Center helped organize a national meeting on cement dermatitis in conjunction with the Occupational Health Foundation in 1995 to discuss these issues. The Consortium identified and generated best practices (such as the use of neutralizing agents for skin washing) for wet cement work and developed a series of user friendly documents for the construction industry.

The Consortium has been instrumental in focusing the cement industry on skin problems and in disseminating information about innovative protective measures such as neutralizing agents.

In 2005, for the OSHA proposed rule for occupational exposure to hexavalent chromium, we collaborated with other NIOSH programs to review the literature on wet cement, dermatitis, and related interventions. We helped prepare NIOSH testimony on the proposed rule.

UV radiation interventions

The Construction Program supported cross-cutting research to examine the mechanisms of dermal toxicity and carcinogenesis of UV radiation and the study of nutritional factors that may play a protective role. A number of studies have been published which document the effects of berry extracts such as blackberry, blueberry and strawberry. They can inhibit growth and attachment of human cancer cells and block the process of injury from UV irradiation. Results of the studies have identified the primary signal transduction pathway for UV induced injury and indicate the role which phytochemicals in berry extracts play in blocking the injury.

These studies have identified cyanidin 3 glucoside, a component of berry extract, as an agent which inhibits skin tumorigenesis, neoplastic transformation, lung cancer growth, and metastasis in animal models. It inhibits cancer cells growth through the induction of a mechanism of cell death (apoptosis) that has recently been implicated as an important component in neoplastic transformation. The agent has also been demonstrated to possess strong antioxidant activity involving, at least, inhibition reactive oxygen species and induction of cytoprotective genes. Based on the results of these studies cyanidin-3-glucoside, has been patented as an antineoplastic agent. (U.S. Patent Application No. 60/643,371, CDC Ref. No. I-023-04)

C) Outputs and Transfer

Construction Program and Center researchers authored a total of 6 peer reviewed journal articles on this topic, provided 3 presentations and developed 10 NIOSH and Center publications.

Surveillance and contact dermatitis

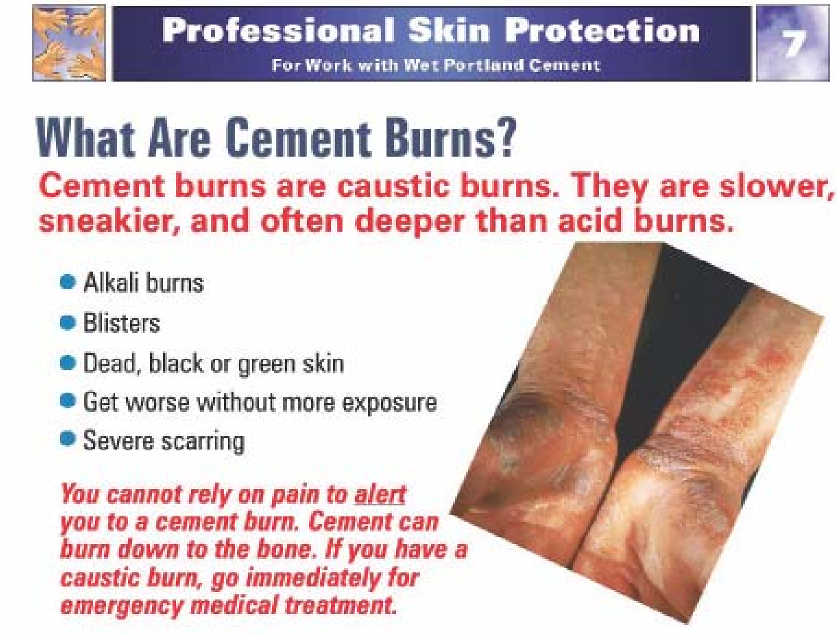
The Construction Chart book includes a page entitled: “Nonfatal Skin Diseases and Disorders in Construction” to provide available surveillance information for the construction community. A job-exposure matrix for materials causing dermatitis in construction was also created. Information on exposures and disease was incorporated into an Access database which identified all the medical and exposure information on contact irritants and allergens used in construction, and linked it to specific crafts and trades. The dermal database is part of the Construction Data Center.[3]

The Construction Program, working with the Consortium on Preventing Contact Dermatitis produced a series of documents for use in the industry:

- *Professional Skin Protection for Work with Wet Cement in Construction Training Program,* 28 slide PowerPoint Presentation with accompanying Instructors Guide for 1- and 2-hour training
- *Employers Guide to Skin Protection for Work With Wet Cement in Construction*, 58 page manual
- *Safety and Health Practitioners Guide to Skin Protection for Work with Wet Cement in Construction*, 42 page manual
- *Save Your Skin A 15-Minute Tool Box Session*, pamphlet
- *Save Your Skin Glove Wear for Wet Cement Work*, pamphlet aimed at workers
- *Physician’s Alert for Occupational Contact Dermatitis Among Construction Workers*, pamphlet aimed at doctors

Approximately 10,000 copies of publications on contact dermatitis have been printed and distributed to interested parties such as construction unions and employer associations associated with the consortium along with other interested unions and construction organizations. The materials are also available for download from eLCOSH (http://www.elcosh.org).

[3] See Subgoal 4.1 for additional information about the Construction Data Center



Other outputs include:

- Hazard Alert: Solvents in Construction
- Hazard Alert: Skin Problems in Construction
- Two articles on this topic appeared in CPWR's newsletters, *Impact* and *On Center.*
  Two articles were or will be published in trade publications: Some construction materials cause serious skin problems. *The Boilermaker Reporter,* March-April 2002. Trahan, Chris, Watters, Mary. Problems that aren't set in stone: Concrete burns, *Occupational Health & Safety*. (in press)

D) Intermediate Outcomes

Surveillance and contact dermatitis
The job exposure matrix developed under the contact dermatitis prevention program has been incorporated into a current construction research project underway by other construction center researchers who are developing the Construction Solutions Database, to address all construction trades hazards and controls.

Examples of others' use of the skin protection documents and hazard alerts Include:

OSHA makes the materials available through links on their web site: http://www.osha.gov/dcsp/products/topics/concreteproducts/industrycontrols.html

The Bricklayers and Allied Craftsmen link to the material on their web site:
http://www.bacweb.org/safety_training/sh_news/04_0506_work_safe_smart.htm
http://www.bacweb.org/news/journal_archive/2001_0506/safety.htm

The National Library of Medicine Medline page for "Skin Conditions" includes a link to the Construction Center *Skin Problems in Construction* Hazard Alert in both English and Spanish:
http://www.nlm.nih.gov/medlineplus/skinconditions.html

The materials are used for training. For example:

The LHSFNA incorporated the dermatitis program into their training programs. The Fund continues to promote the program to raise awareness on the issue and provide solutions. The Fund staff estimated the materials have been used in training between 200 and 600 laborers through use of the program at about 20 training centers. LHSFNA safety and health staff report that contractors have stated they have changed job site practices as a result of the awareness training provided with the CPWR materials.

The Operative Plasterers & Cement Masons International Association (OPCMIA) uses the materials in apprentice, journeyman upgrade and jobsite toolbox training, and gives the workers material for informational medical awareness to member's physicians. Eighty training centers use the program, and 15,000 plasterers have been trained with it.

The Association of the Wall and Ceiling Industry published an article on the union training programs in its newsletter. AWCI's website states it has more than 2,000 members that are primarily wall and ceiling contractors, product suppliers or product manufacturers in all 50 states and many countries. The contractor portion of the membership accounts for 50% of related construction volume in the United States.

The American Society of Concrete Contractors includes the employers guide and the safety and health practitioners guide in the skin safety kit distributed to employers. Refererence:
https://resources.myeporia.com/company_111/2005%20November.pdf
http://www.ascconline.org/category.asp?cat=SAFETY%20AND%20INSURANCE

Wisconsin OSHA reprinted the *Prevent Occupational Contact Dermatitis* brochure in their newsletter.

The Center provided technical information about cement-related contact dermatitis and best prevention practices upon request of the Building and Construction Trades Department (BCTD). BCTD wanted the information to provide input about the OSHA proposed rule for hexavalent chromium. We also provided technical advice on the question of adding ferrous sulfate during the manufacture of cement as an engineering approach to reducing the hexavalent chromium concentration. The BCTD took the position that if the hexavalent chromium in Portland cement was over 2 ppm (the European standard) then the contractor would be subject to the hexavalent chromium standard. The testimony also advocated hand washing to control the hazard as another primary way to reduce disease.

OSHA did use NIOSH testimony in support of their final rule on hexavalent chromium although they decided to pursue an alternative approach relying on existing OSHA provisions to address wet cement issues.

UV radiation interventions

The antineoplastic agents in berry extract and NIOSH's role in this research was described in a press release by the US Agricultural Research Service http://www.ars.usda.gov/is/pr/2006/060920.html.

E) External Factors

For various reasons, OSHA decided not to include wet cement under the scope of the hexavalent chromium standard. A settlement agreement will result in a checklist to highlight the existing OSHA provisions which can be used to address dermal hazards from wet cement. This is likely to raise awareness about wet cement dermatitis issues and lead to increased prevention activities.

F) What's Ahead?

CPWR is currently working to finalize the *Safety and Health Practitioners' Guide to Working with Epoxy Resins*. Once it is completed, we will distribute it to the construction trade unions and contractor groups using epoxies, and encourage them to incorporate it into their training as they did with the information on Portland cement.

NIOSH is in the final stages of developing a welding generation and exposure system, the design can be used to assess the potential hazard from UV exposures during welding. The potential dermal hazard from UV exposure is one of the focus areas which will be incorporated into future exposures as the welding generation and exposure system is brought into use.

The Construction Program developed a draft strategic goal to reduce dermal exposure and associated illnesses among construction workers and will consider this topic further as goals are finalized.

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Sub goal 2.6 Welding Fume Exposures and Various Health Effects

A) Issue

Welding and related processes such as brazing and thermal cutting are routinely performed by construction workers including pipefitters, sheet metal workers, ironworkers, and boilermakers. Several other trades perform occasional welding. Official estimates of the number of construction welders are not available but national estimates across all sectors suggest more than 410,000 workers weld, braze, cut or solder full-time, with more than a million welding on an intermittent basis [NIOSH 2003, Antonini 2003].

Welding presents a complex exposure picture. The process creates noise, heat, UV radiation, gases, electromagnetic radiation, and fumes. The type and amount of contaminants generated vary based on factors such as the type of welding being performed,[4] the base metal being worked on, the presence of any coatings, and the work setting conditions. Metal fume characteristics (e.g., particle size distribution, distribution of metals, fume surface area) will also vary.

Health effect studies on welders have reported respiratory and other organ system effects including elevated cancer risk. Epidemiology studies have shown that a large number of welders experience some type of respiratory illness. Key health effects seen in full-time welders include airway irritation, bronchitis, chemical pneumonitis, lung function changes, asthma, and a possible increase in the incidence of lung cancer [NIOSH 2003]. Pulmonary susceptibility to infections is also increased in welders [Antonini 2003]. In addition, adverse skin reactions and potential decrements in neurological function have been reported. However, little information exists about causality, dose-response, and possible underlying mechanisms regarding the exposure to welding fumes. Even less information is available about the local and systemic immune effects after welding fume exposure.

NIOSH published a *Criteria Document for Welding, Brazing and Thermal Cutting* in 1988 prior to the creation of the Construction Program [NIOSH 1988]. It recommended that "all welding emissions be reduced to the lowest feasible concentration using state-of-the-art engineering controls and work practices." The International Agency for Research on Cancer (IARC) reviewed the health effects literature for welding in 1990 and found that welding fumes are "possibly carcinogenic."

Concerns about welding health effects have increased among construction employers and workers based on increasing awareness about two important welding-related contaminants: Cr(VI) and manganese. Cr(VI) is primarily a concern when welding on stainless steel but may also be present in small

[4] The most common welding types include FCAW (Flux-Cored Arc Welding); SMAW (Shielded Metal Arc Welding); GMAW (Gas Metal Arc Welding); and SAW (Submerged Arc Welding).

amounts in mild steel. Cr(VI) has been associated with lung cancer and occupational asthma and was recently regulated by OSHA. The OSHA health standard lowered the Permissible Exposure Limit (PEL) for Cr(VI) to 5 ug/m^3 and requires training, exposure monitoring, and other protective measures. Manganese is found in steels, filler metals and electrodes and has been associated in some studies with neurological conditions similar to Parkinson's disease.

The complexity and variety associated with welding contaminant mixtures present a challenge to characterizing exposures and to understanding causality, dose-response, and underlying health effect mechanisms. Carcinogenicity and inhalation toxicology studies of welding fumes in animals are lacking or incomplete.

Construction Program and Construction Center researchers have focused efforts on several welding fume data gaps. We partnered with other NIOSH programs to support cross-cutting intramural research to develop fundamental methods needed to examine health effects. We characterized welding fume exposures for various trades and tasks, especially those associated with contaminants of concern such as manganese and Cr(VI). An additional emphasis has been intervention research on control of welding fumes.

B) Activities

Methods Research

In order to conduct toxicology studies on welding fumes, a method to reliably generate fumes was necessary. With the help of welding industry partners, Construction Program researchers designed a laboratory welding fume generator. The device uses a robotic arm that can be programmed to weld at specific intensities, using specified techniques, for given durations. This device allows NIOSH to generate welding fumes under realistic conditions. An exhaust trunk in the arm collects the resulting welding fumes, which are transported to a closed chamber, diluted, and then introduced into a laboratory exposure chamber for further use in exposure tests.

Construction Program researchers developed two new sample collection and analysis methods to measure Cr(VI) in welding fumes. These include field-based methods designed to reduce sample analysis turnaround time – an important issue for construction conditions and jobs.

Health Effects Research

The Construction Program is supporting in-house research using the welding fume generator for animal studies addressing dose-response and time course and underlying mechanisms of pulmonary, immune, and central nervous system responses. Construction Program researchers have conducted planning and evaluation to identify data needs and research directions to evaluate health hazards from welding.

We summarized available health effects research on welding fumes and provided Cr(VI) risk assessments for use by OSHA. In 2005, NIOSH convened a meeting of experts to provide their scientific opinions on the interpretation of neurological effects (e.g., parkinsonism) observed in welders.

Researchers have pursued partnerships to increase the resources available for health effects research. A partnership on neurotoxicity testing was developed with Vanderbilt University (funded by the Department of Defense) to evaluate the effect of manganese in welding fumes on neurotoxicity in laboratory animals. Construction Program researchers also prepared nomination and supporting documentation for welding fumes to undergo additional chronic inhalation testing through the National Toxicology Program.

Exposure Characterization
Construction Program researchers have performed lab-based studies to characterize effects of welding materials and operational parameters on the composition, structure, size, and formation mechanisms of welding fume particles. These have resulted in focused studies on the key toxic components of welding fumes and their relationship to specific workplace conditions.

Construction Center researchers have used task-based exposure methods ("T-BEAM" - Task-Based Exposure Assessment Model) to characterize welding fume exposures. These studies, which began in 1993, used a standardized approach to exposure assessment that could be applied to construction. Statistical analysis of collected data was used to determine whether or not estimates of exposure could be made for construction workers absent a fixed worksite. T-BEAM partners industrial hygienists with journey-level workers in the exposure assessment process and emphasizes the identification and evaluation of engineering controls. The Construction Center's T-BEAM project demonstrated that use of local exhaust or mechanical ventilation reduced exposures to welding fumes among sampled welders by as much as 44% based on exposure data collected between 1995–1996 [Rappaport1999].

The Construction Center has partnered with a number of unions, contractors, and owners, and the Building and Construction Trades Department (BCTD), AFL-CIO. For example, partners have included the following groups:

- International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers;
- International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers; and
- United Association of Journeymen and Apprentices of the Plumbing and Pipe-fitting Industry of the United States and Canada

Tasks and settings examined for T-BEAM include welding and thermal cutting during oil refinery maintenance work, pipe fabrication, bridge rehabilitation, new construction of semiconductor plants, and rehabilitation projects at a pulp and paper mill and aerospace facility.

At OSHA's request, Construction Program researchers evaluated Cr(VI) exposures at a cross-section of facilities, including construction operations involving welding.

Intervention Research
In January, 2005, as part of the Tools and Programs for Improving Occupational Health Conditions in Construction (TAPs) Project, the Construction Center evaluated the effectiveness of a portable ventilation unit for welding for reducing manganese and Cr(VI) exposures among pipefitters. Randomized, repeat sampling trials conducted at Pipefitters Local Union 120 Training Center in

Cleveland showed that a portable local exhaust ventilation unit cut manganese exposure four-fold during carbon steel welding and reduced Cr(VI) exposure levels 55% during stainless steel welding.

Construction Program researchers performed a number of control technology assessments to evaluate local exhaust ventilation (LEV) options including welding equipment with built-in fume extraction systems. Tasks and settings examined include boiler rehabilitation, vocational school welding programs, and apprenticeship school welding programs.

Working with the partners previously mentioned, Construction Center researchers introduced LEV onto welding sites in 1996. In addition, we did videography and real-time monitoring of an ironworker welding shop in Philadelphia to graphically depict the impact of proper positioning of LEV to reduce welding fume exposure.

In 2006, following verification that the portable LEV unit worked in a controlled setting, Construction Center researchers tested the equipment on a new construction project – the University of Michigan School of Public Health addition in Ann Arbor. Use of the portable LEV resulted in a 53% reduction in manganese exposure among sampled welders.

C) Outputs and Transfer

Construction Program and Center researchers authored a total of 45 peer reviewed journal articles on this topic, provided 38 presentations and developed 3 NIOSH and Center publications.

Methods Research

Construction Program researchers authored a peer-reviewed article on the robotic welding fume generator for laboratory animals [Antonini et al. 2006a].

Two new NIOSH methods were published for determining Cr VI in workplace air samples:

- NIOSH Method 7605, hotplate extraction in basic buffer and ion chromatographic detection of Cr VI
- NIOSH Method 7703, field-based ultrasonic extraction and spectrophotometric detection of Cr VI.(patented and available for commercial application).

Health Effects Research

Construction Program researchers authored a peer-reviewed publication that provides an overall review of the welding health effects literature [Antonini 2003], and one that addresses pulmonary responses to welding fumes [Antonini et al. 2003].

Outputs also addressed welding contaminants of special concern such as manganese and Cr(VI) [Park et al. 2005, Park et al. 2006, Antonini et al. 2006b].

To help transfer findings, the Construction Program provided support to the international conference, *Health Effects of Welding*, held in July 2005 in Morgantown, West Virginia (150 attendees). The conference was co-sponsored by the National Institute of Environmental Health Sciences (NIEHS), the Association of Occupational and Environmental Clinics, and West Virginia University. Construction Program researchers also participate on the American Welding Society Safety and Health Committee as a mechanism to transfer health effects and other information.

In addition, Construction Program researchers participated in developing NIOSH comments to OSHA on the proposed Cr(VI) standard. These comments addressed health effects and risk assessment issues.

Exposure Characterization

Lab-based researchers have authored publications such as *Characterization of the Aerosols Resulting from Arc Welding Processes* [Zimmer and Biswas 2001] and *The Influence of Metallurgy on the Formation of Welding Aerosols* [Zimmer 2002].

The Construction Center's T-BEAM project characterized welding fume exposures at 12 sites around the United States [Susi et al. 2000] and distributed to unions, contractors and workers who participated in field surveys. Study findings were also presented at both union and professional meetings. Field research publications include *Construction Welding Exposures to Manganese Likely to Exceed Proposed TLV* [Welch et al. 2004]; *The use of a Task-based Exposure Assessment Model (T-BEAM) for Assessment of Metal Fume Exposures during Welding and Thermal Cutting* [Susi et al. 2000]; and Assessment of Students' Exposure to Welding Fumes in a Vocational School Welding Shop [Wallace 1997].

Given the high level of interest and concern associated with manganese exposures, Construction Center researchers presented findings on welding health effects, exposures, and controls upon request to the National Erectors Association (NEA) Local Employer Organizations Meeting in April 2004, and to the NEA Safety & Health/Labor Forum in May 2004.

In addition to peer-reviewed publications and meetings, Construction Center researchers have produced publications and videos for construction worker and contractor audiences. A welding and gases hazard alert was also developed; it is available on the web (www.elcosh.org) and has been distributed through the Center's communication department.

Intervention Research
Engineering controls for health hazards in construction, including welding fumes, are scarce in construction. Because the industry has limited experience with use of controls such as LEV, there is a great need for research identifying controls that are likely to work in the transient, mobile realm of construction. Filling this need is of increased importance since for welding trades such as sheet metal workers and pipefitters, the projected employment growth between 2002 through 2012 is at about 23% [FMI 2005].[5]

Research results on welding controls were shared via an annual engineering and work practice controls work group meeting attended by labor, government, industry representatives, and researchers. This group also assisted in shaping engineering controls research.

The Construction Center produced and disseminated engineering controls research products through both print and visual media. Examples include:

- A video that shows the impact of LEV, *Welding – A Control Technology Evaluation*. Posted on eLCOSH, the electronic Library of Construction Occupational Safety and Health, the video has been distributed to welding instructors for use in training programs throughout the United States.
- A Center newsletter sent to more than 3,500 and circulated at meetings with labor and industry groups.
- Coordination and communication with Joint Apprenticeship and Training Programs.

D) Intermediate Outcomes

Methods
The National Toxicology Program (NTP) is using the welding fume generation and animal exposure system developed by Construction Program researchers for NTP-sponsored chronic animal studies. The analytical methods developed have been incorporated into national and international consensus standards [ISO 2005, ASTM 2005]. And Construction Program researchers have made contributions to a number of guidelines published by the American National Standards Institute [ANSI/AWS 1999a, ANSI/AWS 1999b, ANSI/AWS 2003].

Health Effects
The Construction Program health effects outputs are have been incorporated into health effects evaluations [AWS 2001; AWS 2003]. In addition, Construction Program investigator, Dr. James Antonini received the American Welding Society Safety and Health Award for 2006. This award is presented annually to an individual who best encourages the advancement of welder safety and health

[5] FMI [2005] The 2005-2006 U.S. Markets Construction Overview. Raleigh, NC

through conducting research and education activities, developing safe practices, or disseminating knowledge through publications or other means.

In part due to the efforts of NIOSH, OSHA reduced the Permissible Exposure Limit (PEL) for Cr VI in recognition of the carcinogenic properties of inhaled chromate compounds.

Exposure Characterization

This information was presented at industry conferences and led to the purchase of LEV units on a recent power plant turn-around project in Washburn, North Dakota that employed approximately 400 construction workers, many of whom were pipefitter and boilermaker welders. In addition, several apprenticeship training directors from the United Association of Plumbers and Pipefitters have used this information to upgrade LEV in their local training centers.

The Ontario Bureau of Workers Compensation used the Construction Center's welding exposure data to estimate manganese exposures among pipefitter claimants.

Intervention Research

The Building and Construction Trades Department (BCTD), AFL-CIO, Safety and Health Committee is made up of building trades unions and plays an important role in communicating among their members, national agencies or organizations including OSHA, NIOSH and CPWR. Information generated by the Construction Center has supported the BCTD with the following:

- Comments and testimony for OSHA's Cr VI rule.
- Informational material for manganese which is posted on the BCTD website (www.bctd.org).
- A Health Hazard Evaluation (HHE) request to NIOSH for manganese and welding in construction.

E) External Factors

With the exception of cadmium, Cr(VI), and lead, there are no OSHA comprehensive health standards associated with welding fumes. NIOSH classifies welding fumes as a carcinogen and recommends that exposures be kept at the lowest feasible concentration through the use of engineering, administrative, and/or personal protection control strategies [DHHA 2005]. The OSHA PEL of 5.0 mg/m^3 for manganese is higher than the ACGIH TLV for manganese: 0.2 mg/m^3.

Given that there is little regulatory impetus for employers to measure and control welding fumes in the workplace, engineering controls such as local exhaust ventilation are still rarely used in construction welding operations, nor is use of respiratory protection widespread. In addition, although several recent peer-reviewed medical publications have described a relationship between welding and manganese with Parkinsonism and/or Manganism, there is little definitive exposure data or epidemiology studies with which to adequately evaluate this risk.

On the other hand, two external factors may promote greater interest in reducing exposure to manganese and Cr(VI): 1) a number of litigations have been filed on behalf of welders who have neurological illnesses which they contend are associated with exposure to manganese fumes, and 2) construction contractors, owner/clients, training directors and others are interested in verifying compliance with OSHA's comprehensive new standard for Cr(VI), effective November 2006.

F) What's Ahead?

Health Effects

Case studies and cross-sectional evaluations of welders have reported neurological effects in welders diagnosed as idiopathic Parkinson's Disease or Parkinsonism. Limited evidence suggests that chronic exposure in certain contemporary welding operations where manganese fumes are generated carries a risk of developing a Parkinson's Disease-like neurological disorder, known as Manganism, with both reversible and irreversible health effects. Construction Program researchers plan to identify and gain access to an appropriate population which will identify exposure levels and time courses of exposure that lead to clinically significant impairment and that would support a quantitative risk assessment. The result would indicate whether current welding practices using high-Mn alloys and welding rods are placing workers at unacceptable risk and would support recommendations for further regulation, if needed. NIOSH also plans to develop a Current Intelligence Bulletin (CIB) that will evaluate the health risks to welders for developing neurological effects from exposure to welding fumes and, if warranted, recommend appropriate preventive measures. In addition to internal evaluation of available data, NIOSH has enlisted experts (beginning with a meeting convened in the spring of 2005) to provide their scientific opinions on the interpretation of neurological effects (e.g., Parkinsonism) observed in welders. A topic page on Welding/Manganese/Parkinsonism is also being developed for posting on the NIOSH website to list relevant information on the topic and to inform the public of the Institute's ongoing evaluation of welders and the risk for developing Parkinsonism.

The welding generation and exposure system developed by Construction Program researchers will be used by the National Toxicology Program (NTP) to conduct studies of the health effects of welding. Without the system, the studies would not be possible. At NIOSH's request, NTP has determined to conduct long-term rodent carcinogenicity and neurotoxicity studies using the NIOSH welding fume generation system design. Construction Program scientists will provide technical advice on exposure system construction and experimental design. The goal of these studies is to replicate exposures encountered in various work environments. These sector profiles will be simulated by the welding generation system for hazard evaluation and used to produce exposures for animal studies. Results are expected to characterize potential health effects and identify the critical welding fume components/issues for control measures. Dose-response and time courses of pulmonary, immune, and central nervous system responses to welding fumes will be conducted to identify hazards for implementation of prevention strategies and data to support risk assessment efforts. Various welding processes with different materials will be evaluated.

Risk assessments will use data from Construction Program and Center researchers, NTP, and other studies. This information will be communicated to OSHA for reevaluation of current standards, which would decrease adverse health effects in welders in the future.

Intervention Research

Plans include:

- Ongoing collection of "real-world" welding fume exposure data to measure the efficacy and effectiveness of portable LEV in a variety of construction settings
- Collection of additional Mn and Cr(VI) data for undersampled trades and welding processes

- Analysis of collected data and additional relevant data sets to determine probability of exceeding occupational exposure limits for Cr(VI) and manganese and to determine impact of various factors (e.g., trade, process, LEV) in contributing to or reducing exposure to welding fumes

- Diffusion of research findings through:
    - Industry and peer-reviewed publications
    - Collaboration with contractors, unions, and equipment manufacturers/suppliers
    - Posting of information on both measured exposures and details on successful means to control exposure on www.cpwr.com and www.elcosh.org
    - Apprenticeship and journeymen training
    - Organizations positioned to encourage use of engineering controls to reduce welding fume exposure through job specifications, collective bargaining language, and standards.

In addition to quantitative evaluations of controls, case studies will be written to describe how control technologies have been effectively used on job sites. Although identification of practical and effective engineering controls is challenging, the far greater challenge is getting such equipment in use by the industry. Descriptions of how controls have been successfully used and/or promoted will help diffuse these practices throughout the industry. Recommendations on control technology research needs as well as strategies for practical application of effective controls will be an important outcome of this project.

The NORA Construction Sector Council identified welding fumes as one of the top three health hazards of concern to focus on in the upcoming decade.

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